The Journal of Foot & Ankle Surgery 56 (2017) 336–356

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Review Article

American College of Foot and Ankle Surgeons® Clinical Consensus Statement: Perioperative Management

Andrew J. Meyr, DPM, FACFAS [1], Roya Mirmiran, DPM, FACFAS [2], Jason Naldo, DPM, FACFAS [3], Brett D. Sachs, DPM, FACFAS [4,5], Naohiro Shibuya, DPM, FACFAS [6]

[1] *Committee Chairperson and Clinical Associate Professor, Department of Surgery, Temple University School of Podiatric Medicine, Philadelphia, PA*
[2] *Surgeon, Sutter Medical Group, Sacramento, CA*
[3] *Assistant Professor, Department of Orthopedic Surgery, Virginia Tech Carilion School of Medicine, Roanoke, VA*
[4] *Private Practice, Rocky Mountain Foot & Ankle Center, Wheat Ridge, CO*
[5] *Faculty, Podiatric Medicine and Surgery Program, Highlands-Presbyterian St. Luke's Medical Center, Denver, CO*
[6] *Professor, Department of Surgery, Texas A&M, College of Medicine, Temple, TX*

A R T I C L E I N F O

Level of Clinical Evidence: 5

Keywords:
body mass index
cigarette smoking
Delphi method
glycated hemoglobin
prophylactic antibiotic
tourniquet
vitamin D

A B S T R A C T

A wide range of factors contribute to the complexity of the management plan for an individual patient, and it is the surgeon's responsibility to consider the clinical variables and to guide the patient through the perioperative period. In an effort to address a number of important variables, the American College of Foot and Ankle Surgeons convened a panel of experts to derive a clinical consensus statement to address selected issues associated with the perioperative management of foot and ankle surgical patients.

Executive Statement

The following represents a clinical consensus statement sponsored by the American College of Foot and Ankle Surgeons® on the topic of perioperative management. A modified Delphi method was undertaken by a 5-member panel in an attempt to develop consensus on a series of 22 statements using not only the best available evidence, but also a degree of clinical experience and common sense.

The panel reached consensus that the following statements were "appropriate":

- *Cigarette smoking should be considered a risk factor for the development of complications after foot and ankle surgical procedures*
- *Elevated glycated hemoglobin should be considered an independent risk factor for the development of complications after foot and ankle surgical procedures*
- *Patients with open foot and ankle fractures should be treated with antibiotics*
- *The urgency of the treatment of open foot and ankle fractures is dependent on a variety of factors, including, but not limited to, time, anatomic location, and fracture grade and extent*
- *Perioperative management of diabetes medications warrants consideration before foot and ankle surgical procedures*
- *Perioperative management of rheumatoid arthritis medications warrants consideration before foot and ankle surgical procedures*
- *Perioperative management of anticoagulation medications warrants consideration before foot and ankle surgical procedures*
- *Tourniquets can be safely used for most patients undergoing foot and ankle surgical procedures*
- *Prophylactic antibiotic therapy should be considered for foot and ankle surgical procedures*
- *Prophylactic postoperative antithrombotic therapy should be considered for some patients after foot and ankle surgical procedures*
- *Foot and ankle surgeons should consider a multimodal approach to postoperative pain management*
- *Foot and ankle surgeons should be aware of objective measures of patient satisfaction and postoperative outcomes*

The panel reached consensus that the following statement was "inappropriate":

Financial Disclosure: None reported.
Conflicts of Interest: None reported.

Address correspondence to: Andrew J. Meyr, DPM, FACFAS, Department of Surgery, Temple University School of Podiatric Medicine, 8th Race Street, Philadelphia, PA 19107.
E-mail address: ajmeyr@gmail.com (A.J. Meyr).

1067-2516/$ - see front matter
http://dx.doi.org/10.1053/j.jfas.2016.10.016

- *Foot and ankle surgeons should use routine postoperative radiographs in the absence of a clinical indication to assess osteotomy, fracture, and/or arthrodesis healing*

The panel reached consensus that the following statements were "neither appropriate nor inappropriate":

- *Foot and ankle surgical procedures should be considered a low perioperative risk*
- *Foot and ankle surgeons should use specific hair removal and preoperative skin bathing protocols before elective foot and ankle surgical procedures*
- *Preoperative methicillin-resistant Staphylococcus aureus decontamination protocols should be performed before elective foot and ankle surgical procedures*
- *An elevated body mass index should be considered a risk factor for the development of complications after foot and ankle surgical procedures*
- *A high preoperative blood glucose level should be considered a risk factor for the development of complications after foot and ankle surgical procedures*
- *Foot and ankle surgical procedures involving arthrodesis of the first ray should use a period of non-weightbearing immobilization*
- *Specific postoperative incisional care protocols should be used by foot and ankle surgeons*

The panel was unable to reach consensus on the following statements:

- *Vitamin D levels should be assessed before all foot and ankle arthrodesis procedures*
- *Foot and ankle surgeons should consider the use of bone stimulation in cases of delayed and nonunion*

Introduction

This document was created to serve as one of a series of clinical consensus statements (CCSs) sponsored by the American College of Foot and Ankle Surgeons® (ACFAS) (1,2). It is important to appreciate that consensus statements do not represent clinical practice guidelines, formal evidence reviews, recommendations, or evidence-based guidelines. A CCS reflects information synthesized from an organized group of experts based on the best available evidence. However, it can also contain, and to some degree, embrace opinions, uncertainties, and minority viewpoints. A CCS should open the door to discussion on a topic, as opposed to attempting to provide definitive answers.

In 2003, Smith and Pell (3) reported what can only be described as a sarcastic systematic review of randomized controlled trials examining the effectiveness of parachutes in preventing death after jumping out of airplanes. Because they were unable to identify any level 1 evidence on the topic, their only possible conclusion within the modern paradigm of evidence-based practice was that parachutes could not be proved to prevent death after free fall. They even went so far as to encourage the proponents of evidence-based medicine to organize and participate in a double-blind, randomized, placebo-controlled, crossover trial of the parachute. Their broad point was that high-level evidence is not always available for all clinical situations and interventions; thus, some amount of common sense is important in contemporary medicine. We think this also represented our primary theme during the construction of this CCS: an attempt to develop consensus on a broad range of topics relevant to the clinical practice of foot and ankle surgeons using not only the best available evidence, but also a degree of clinical experience and common sense.

Adherence to consensus statements will not ensure successful treatment in every clinical situation, and individual physicians should make their ultimate decisions using all available clinical information and circumstances with respect to the appropriate treatment of an individual patient. This CCS is on the general topic of perioperative management of the foot and ankle surgical patient, and its purpose is to address some of the preoperative, intraoperative, and postoperative considerations facing the foot and ankle surgeon in contemporary practice.

Materials and Methods

Creation of the Panel

Believing that the creation of CCSs would be beneficial to its members, the ACFAS enacted an initiative to create such documents for foot and ankle surgeons. This initiative was originally conceived to report on a variety of topics and to replace previous clinical practice guidelines (4–10). To move forward with this initiative, a formal consensus method process was undertaken. Seven experts in the field of foot and ankle surgery were initially sent an invitation by the ACFAS to participate on a panel to develop a CCS on "perioperative management." A 5-member panel was eventually convened and tasked with reviewing the published medical data and providing opinions about this topic. The panel was chaired by 1 member (A.J.M.) and assisted by ACFAS members and staff. During a several-month period, the panel members participated in an electronic mail dialog, conference calls, and a face-to-face meeting. The stated goal of the panel was to develop a series of CCS questions on the topic of perioperative management that might be of interest and value to foot and ankle surgeons, examine the current published data relating to these statement questions, and synthesize this information and our consensus opinions for ACFAS members and *The Journal of Foot and Ankle Surgery*® readers.

Development of CCS Questions

Our first task was the development of a series of CCS questions for inclusion. The topic of perioperative management is broad, and any number of subtopics and specific statement questions could be derived from it. Initially, through ACFAS member survey feedback, our collective clinical experience, and the results of an open discussion during an introductory conference call, we developed a preliminary list of approximately 35 to 40 specific topics within the realm of perioperative management to consider as consensus statement questions for inclusion in this CCS. The panel members subsequently performed preliminary data reviews and wrote brief synopses on these topics, attempting to answer the questions of (1) whether any guidelines exist on this topic; (2) whether any original investigations have been reported on this topic specific to the foot and ankle; and (3) whether any other original investigations have been reported on this topic specific to other medical specialties, but still potentially relevant. On a subsequent conference call, these initial reviews and synopses were discussed, and the panel made majority decisions resulting in the inclusion and development of 22 CCS questions (Table).

Formal Literature Review

Comprehensive reviews of the published data were then performed by the panel members and included searches of Medline®, EMBASE®, the Cochrane Database of Systematic Reviews, and manual searches of the references of the included articles. Although this was not a formal systematic review, each panel member conducted thorough literature searches using these databases in an attempt to answer specific questions on each topic. The data searches included at least all prospective clinical trials, retrospective clinical cohort analyses, and retrospective case series specifically involving foot and ankle surgery on the respective topics.

Consensus

A modified Delphi method was then used to attain consensus on the clinical questions by the members of the panel (11). The series of 22 statement questions was developed by the panel chairperson and sent to all panel members to review and answer. The answers were determined by the appropriateness of the statement question and were graded from 1 (extremely inappropriate) to 9 (extremely appropriate) using a Likert scale (12). Each panel member initially answered the questions anonymously, and the results were returned to the panel chairperson. The answers were reviewed, analyzed, and grouped from 1 to 3 (inappropriate), 4 to 6 (neither inappropriate nor appropriate), and 7 to 9 (appropriate). The results were summarized with basic descriptive statistics, kept anonymous, and distributed back to the panel members. At the face-to-face meeting, the questions and initial consensus results were reviewed and opened to discussion. Although an attempt was made to reach consensus

Table
Clinical consensus statement questions and results

Preoperative Considerations								
1. Foot and ankle surgical procedures should be considered low perioperative risk.								
1	2	3	**4**	**5**	**6**	7	8	9
Extremely inappropriate								Extremely appropriate
2. Foot and ankle surgeons should use specific hair removal and preoperative skin bathing protocols before elective foot and ankle surgical procedures.								
1	2	3	**4**	**5**	**6**	7	8	9
Extremely inappropriate								Extremely appropriate
3. Preoperative methicillin-resistant *S. aureus* decontamination protocols should be performed before elective foot and ankle surgical procedures.								
1	2	3	**4**	**5**	**6**	7	8	9
Extremely inappropriate								Extremely appropriate
4. Cigarette smoking should be considered a risk factor for the development of complication following foot and ankle surgical procedures.								
1	2	3	4	5	6	**7**	**8**	**9**
Extremely inappropriate								Extremely appropriate
5. An elevated body mass index should be considered a risk factor for the development of complications following foot and ankle surgical procedures.								
1	2	3	**4**	**5**	**6**	7	8	9
Extremely inappropriate								Extremely appropriate
6. Elevated glycated hemoglobin should be considered an independent risk factor for the development of complications following foot and ankle surgical procedures.								
1	2	3	4	5	6	**7**	**8**	**9**
Extremely inappropriate								Extremely appropriate
7. A high preoperative blood glucose level should be considered a risk factor for the development of complications after foot and ankle surgical procedures.								
1	2	3	**4**	**5**	**6**	7	8	9
Extremely inappropriate								Extremely appropriate
8. Vitamin D levels should be assessed before all foot and ankle arthrodesis procedures (No consensus).								
1	2	3	4	5	6	7	8	9
Extremely inappropriate								Extremely appropriate
Direct Perioperative Considerations								
9. Patients with open foot and ankle fractures should be treated with antibiotics.								
1	2	3	4	5	6	**7**	**8**	**9**
Extremely inappropriate								Extremely appropriate
10. The urgency of the treatment of open foot and ankle fractures is dependent on a variety of factors including, but not limited to, time, anatomic location, and fracture grade and extent.								
1	2	3	4	5	6	**7**	**8**	**9**
Extremely inappropriate								Extremely appropriate
11. Perioperative management of diabetes medications warrants consideration before foot and ankle surgical procedures.								
1	2	3	4	5	6	**7**	**8**	**9**
Extremely inappropriate								Extremely appropriate
12. Perioperative management of rheumatoid arthritis medications warrants consideration before foot and ankle surgical procedures.								
1	2	3	4	5	6	**7**	**8**	**9**
Extremely inappropriate								Extremely appropriate
13. Perioperative management of anticoagulation medications warrants consideration before foot and ankle surgical procedures.								
1	2	3	4	5	6	**7**	**8**	**9**
Extremely inappropriate								Extremely appropriate
14. Tourniquets can be safely used for most patients undergoing foot and ankle surgical procedures.								
1	2	3	4	5	6	**7**	**8**	**9**
Extremely inappropriate								Extremely appropriate

(*continued on next page*)

Table (*continued*)

Direct Perioperative Considerations								
15. Prophylactic antibiotic therapy should be considered for foot and ankle surgical procedures.								
1	2	3	4	5	6	**7**	**8**	**9**
Extremely inappropriate								Extremely appropriate
Postoperative Considerations								
16. Prophylactic postoperative antithrombotic therapy should be considered for some patients after foot and ankle surgical procedures.								
1	2	3	4	5	6	**7**	**8**	**9**
Extremely inappropriate								Extremely appropriate
17. Foot and ankle surgeons should consider a multimodal approach to postoperative pain management.								
1	2	3	4	5	6	**7**	**8**	**9**
Extremely inappropriate								Extremely appropriate
18. Foot and ankle surgical procedures involving arthrodesis of the first ray should use a period of non-weightbearing immobilization.								
1	2	3	**4**	**5**	**6**	7	8	9
Extremely inappropriate								Extremely appropriate
19. Foot and ankle surgeons should use routine postoperative radiographs in the absence of a clinical indication to assess osteotomy, fracture, and/or arthrodesis healing.								
1	**2**	**3**	4	5	6	7	8	9
Extremely inappropriate								Extremely appropriate
20. Specific postoperative incisional care protocols should be used by foot and ankle surgeons.								
1	2	3	**4**	**5**	**6**	7	8	9
Extremely inappropriate								Extremely appropriate
21. Foot and ankle surgeons should consider the use of bone stimulation in cases of delayed union and nonunion (No consensus).								
1	2	3	4	5	6	7	8	9
Extremely inappropriate								Extremely appropriate
22. Foot and ankle surgeons should be aware of objective measures of patient satisfaction and postoperative outcomes.								
1	2	3	4	5	6	**7**	**8**	**9**
Extremely inappropriate								Extremely appropriate

Values in bold indicate the consensus of the 5-member panel.

for all questions, it was not a requirement, and, in fact, contrary opinions were encouraged. All panel members participated in the creation of the CCS manuscript, the final draft of which was subsequently submitted to the ACFAS leadership for adoption and to *The Journal of Foot and Ankle Surgery*® for publication.

Results and Discussion

Preoperative Considerations

> ***Consensus statement*: The panel reached consensus that the statement "Foot and ankle surgical procedures should be considered low perioperative risk" was <u>neither appropriate nor inappropriate</u>.**

Although it is likely that most foot and ankle surgical procedures should be considered low perioperative risk, for a number of situations our panel concluded that perioperative risk could increase to an elevated risk category.

Patient perioperative risk is traditionally thought of in objective terms as the development of a major adverse cardiac event (MACE) and, unsurprisingly, determining this risk is a complex and multifactorial process. Recent guidelines published by the American College of Cardiology and the American Heart Association defined a "low risk" procedure as one in which the risk of a MACE is $<1\%$, and an "elevated risk" procedure is one in which the risk of MACE is $\geq 1\%$ (13). Note that the terms "moderate risk" and "high risk" were not used, and, instead, the term "elevated risk" was used to describe any procedure with risk of a MACE of $\geq 1\%$.

Determining this risk is both patient and procedure dependent. In terms of procedure-specific considerations, surgeries have conventionally been categorized into "high-risk procedures" (including but not limited to intrathoracic procedures, intraperitoneal procedures, and some peripheral vascular surgeries), "intermediate-risk procedures" (including, but not limited to, head and neck surgery, major neurologic surgery, major orthopedic surgery, endovascular procedures, pulmonary procedures, major urologic procedures, and so forth), and "low-risk procedures" (including minor orthopedic procedures, dental procedures, breast procedures, minor urologic procedures, and so forth) (14). These categories carry a corresponding estimated risk of a MACE of approximately $>5\%$, 1% to 5%, and $<1\%$ (14). Although no clear objective definition of the difference between a "major" and "minor" orthopedic procedure is available, as a reference, total hip and knee arthroplasty procedures are generally considered "major" (15). It is likely that most osseous foot and ankle specific procedures would be considered "minor orthopedic surgery"; however, several procedures (i.e., tibiotalocalcaneal arthrodesis with intramedullary reaming, total ankle arthroplasty, Charcot reconstruction) could be argued to rise to the level of "major orthopedic surgery." Furthermore, foot and ankle limb preservation procedures can be performed in conjunction with higher risk endovascular procedures or open arterial bypass. The specific type of anesthetic technique used would also be expected to influence the procedure-dependent risk.

In terms of patient-specific considerations, several classification systems can be used to assist physicians in objectifying risk. Perhaps the most common is the American Society of Anesthesiologists (ASA) physical status (PS) classification, which defines normal healthy patients as type 1, patients with mild systemic disease as type 2, patients with severe systemic disease as type 3, patients with severe systemic disease that is a constant threat to life as type 4, moribund patients who are not expected to survive the operation as type 5, and patients who have been declared brain dead but undergoing organ harvest as type 6 (16). The ASA PS also includes a type E prefix for patients undergoing emergency procedures. A degree of subjectivity exists between type 2 “mild systemic disease” and type 3 “severe systemic disease.” Conventionally “mild” conditions are “well-controlled” and “severe” conditions are “uncontrolled” (16). This might be most applicable with respect to the foot and ankle when considering the diagnoses of diabetes mellitus and hypertension. Although it is not uncommon for published case series to include ASA PS information within the patient demographic data, we identified 1 study specific to the foot and ankle that had evaluated the “safety” of an anesthetic technique (17). Their review examined 110 consecutive ASA PS level 3 and 4 patients undergoing limb preservation surgery, which speaks to the potential scenario of performing foot and ankle surgery on relatively high ASA PS patients.

Although the ASA PS classification is widely recognized and used, several other systems might offer a greater degree of specificity. The American College of Surgeons National Surgical Quality Improvement Program has developed a risk calculator with an online component (available at: http://riskcalculator.facs.org/). This risk calculator takes into account the type of procedure (using the Current Procedural Terminology code) and a number of patient factors, including age, functional status, ASA class, steroid use, systemic sepsis within 48 hours of surgery, the presence of diabetes, the presence of hypertension requiring medication, previous cardiac event, the presence of congestive heart failure, the presence of dyspnea, smoking history, a history of chronic obstructive pulmonary disease, the need for dialysis, the presence of acute renal failure, and body mass index (BMI) (18). The calculator then produces an objective number for the estimated risk of a serious complication, any complication, pneumonia development, a cardiac complication, a surgical site infection (SSI), a urinary tract infection, venous thromboembolism, renal failure, a return to the operating room, death, discharge to a rehabilitation facility, and the predicted length of stay. For example, a 65-year-old male with a history of insulin-dependent diabetes, hypertension, smoking, and obesity undergoing an emergency bimalleolar ankle fracture with open reduction and internal fixation (ORIF) carries a 10.0% risk of a serious complication, a 12.1% risk of any complication, a 1.3% risk of a cardiac complication, and a 0.8% risk of death. This, again, at least speaks to the potential for foot and ankle surgery to carry an elevated risk. Another resource with an online calculator is the revised cardiac risk index (available at: http://www.mdcalc.com/revised-cardiac-risk-index-for-pre-operative-risk/). This also provides an objective measurement of estimated cardiac risk by accounting for high-risk versus intermediate- or low-risk procedures, a history of ischemic cardiac disease, a history of congestive heart failure, a history of cerebrovascular disease, creatinine level, and preoperative treatment with insulin (19). Both of these tools emphasize the broader point that the term “medical clearance” for the operating room is a misnomer. All surgeries are associated with some perioperative risk, and the goal of a preoperative medical evaluation should be to objectify the risk, with the understanding that the risk can never be completely eliminated.

If it is accepted that a “low-risk” procedure is one in which the incidence of a MACE is <1%, we can conclude that most, but not all, foot and ankle surgical procedures are likely to be low risk.

***Consensus statement*: The panel reached consensus that the statement “Foot and ankle surgeons should use specific hair removal and preoperative skin bathing protocols before elective foot and ankle surgical procedures” was neither appropriate nor inappropriate.**

We identified no consensus within our panel for a clear benefit or detriment to specific hair removal and/or bathing protocols before elective foot and ankle surgery. The panel did not conclude that these techniques were inappropriate; rather, we did not identify a clear positive or negative effect to support consistent implementation of specific preoperative measures.

The preoperative removal of hair from the surgical field is a practice that has been used for many years as a method to decrease the potential for surgical site contamination and, therefore, SSIs. However, contemporary debate has ensued over the effectiveness of hair removal in decreasing SSIs and an increasing body of evidence of some possible negative effects that hair removal might have as it relates to postoperative complications. Evidence on this topic has primarily been derived from other surgical specialties and not specifically from the foot and ankle specialty. A 2011 Cochrane review on preoperative hair removal found “no statistically significant effect on surgical site infection rates” (20). In another meta-analysis of 19 randomized controlled trials, shaving with a razor was significantly associated with a more frequent occurrence of SSIs compared with clipping, chemical depilation, or no hair removal (21). Another comparative analysis evaluated patients undergoing general surgery procedures, specifically comparing hair removed with a razor to hair removed with a depilatory cream and found a significant difference in postoperative infection rates (12.8% versus 2.5%, respectfully) (22). An increasing number of opponents to using a razor for hair removal have argued that it disrupts the normal skin flora homeostasis, can disrupt the bacteria present in hair follicles, and that the use of contaminated razors could lead to postoperative infection (23). We concluded that hair can likely be safely removed preoperatively, although preferably with a clipper or depilation cream and not a razor.

Similarly, the practice of preoperative bathing or skin cleansing before the formal surgical preparation is a commonly performed practice that does not appear to have clear supporting evidence of a substantial benefit. A prospective cohort study was reported within the foot and ankle literature evaluating the effects of a single preoperative chlorhexidine foot bath 20 minutes before elective foot surgery and revealed a decrease in positive culture results but no difference in the incidence of SSIs between the control and intervention groups (24). Another Cochrane review of 10,157 participants did not demonstrate substantial evidence for preoperative showering or bathing with chlorhexidine compared with other products such as soap to reduce the incidence of SSIs (25). Additionally, a separate meta-analysis reviewed 16 trials with 17,932 patients and found that chlorhexidine bathing did not reduce the incidence of SSIs compared with detergent, soap, placebo, or no bathing protocol (26).

***Consensus statement*: The panel reached consensus that the statement “Preoperative methicillin-resistant *Staphylococcus aureus* decontamination protocols should be performed before elective foot and ankle surgical procedures” was neither appropriate nor inappropriate.**

Although a fair amount of clinical evidence supports preoperative methicillin-resistant *Staphylococcus aureus* (MRSA) decontamination protocols before elective surgery, our panel did not reach consensus that this was universally appropriate for the foot and ankle. The panel did not conclude that these techniques were inappropriate but also did not identify a clear positive or negative effect of consistently implementing this specific preoperative measure.

This is a topic that on the surface would appear to make intuitive sense. Several sources, including the Centers for Disease Control and Prevention have recognized that preoperative colonization with *S. aureus* (SA) is a risk factor for the development of a SSI (27–29), and this might be even more applicable for those colonized with MRSA. Kalra et al (30) found that rates of MRSA SSI development were significantly greater in those preoperatively colonized with MRSA compared with those not colonized (1.86% versus 0.20%; $p < .0001$). Both Kalra et al (30) and Gupta et al (31) found an approximate 9 times greater odds of developing a MRSA SSI in those preoperatively colonized with MRSA. Furthermore, a substantial percentage of patients undergoing lower extremity orthopedic surgery are likely to be colonized with either SA and/or MRSA. An investigation by Price et al (32) of 284 patients undergoing orthopedic surgery, including the foot and ankle, found that 86 (30%) were colonized with either SA or MRSA. Although 30% is a substantial proportion of patients, we believe it is important to note that this still represents a minority of patients.

However, despite knowledge that some of our patients might be colonized with SA and MRSA and that this might increase the risk of a postoperative infection, preoperative decolonization protocols might not have a significant preventative effect on the development of a SSI. In the study by Price et al (32), low rates of SSI were observed whether or not the patients were colonized and whether or not the patients underwent decolonization. Additionally, the investigators did not identify a specific risk with procedures involving the foot and ankle. In another study of patients undergoing elective orthopedic surgery, Kim et al (33) did not find a significant difference between SSI rates among noncarriers (0.14%) and MSSA carriers (0.19%). In another prospective study of patients undergoing cardiac, hip, or knee surgery, no significant differences were noted in SSI rates among patients who had undergone a decontamination process (0.20% rate of infection) compared with those not undergoing decontamination (0.35% rate of infection) (34).

In contrast, other studies seem to point toward a positive effect of screening and decontamination protocols. Hacek et al (35) studied 912 patients who were screened before hip or knee replacement, 75% of whom were negative for SA colonization and demonstrated a 0.6% rate of infection. The 25% of patients who were SA carriers and underwent decontamination before surgery had a 1.3% rate of infection. The SSI rate for the patients who were neither screened nor treated was 1.7%. Chen et al (36,37) in 2013 recommended decolonization for patients undergoing total joint replacement because of the significant reduction in MRSA infection after decontamination (4.6% decreased to 0%).

Although studies have advocated the use of decontamination in cardiac, spinal, and total joint replacement procedures, little conclusive evidence is available to support the universal use of such practices in general or for the foot and ankle specifically. Certainly, some reduction in postoperative infection rates might occur when SA or MRSA carriers undergo decontamination; however, this might not always be statistically or clinically significant. Moreover, in our review of the published data, decontamination protocols often varied considerably among practices and hospitals. Many of the protocols recommended the use of intranasal mupirocin twice daily for 5 days, with chlorhexidine showers for 5 days before surgery (33,34,36–40). Other protocols involved used mupirocin for 5 days, but chlorhexidine bathing was used for 1 day before surgery (41). We did not identify a specific “standard of care” decontamination protocol and it would likely be difficult to develop one owing to the variations in patient populations and microbiologic demographics.

***Consensus statement*: The panel reached consensus that the statement “Cigarette smoking should be considered a risk factor for the development of complications after foot and ankle surgical procedures” was <u>appropriate</u>.**

The numerous negative effects of cigarette smoking on the physiology of the human body, in addition to the increased perioperative risks of patients who smoke, have been well documented (42–48). This is primarily due to the effects of nicotine and carbon monoxide resulting in vasoconstriction, decreased microperfusion, decreased tissue oxygenation, endothelial damage, increased blood viscosity, and hypercoagulation (42). We reached consensus that tobacco use in the form of cigarette smoking should be considered a risk factor for the development of complications after foot and ankle surgical procedures and that patients who smoke should be educated on the potential complications of this activity before undergoing foot and ankle surgery.

We identified several investigations examining foot and ankle surgical outcomes in relation to cigarette smoking. Krannitz et al (49) found that in active smokers, a distal first metatarsal osteotomy for the surgical correction of hallux abductovalgus required 1.73 times longer to radiographically heal compared with nonsmokers. In another investigation examining elective forefoot surgery, smokers were 4.3 times as likely to develop any complication and demonstrated greater rates of delayed union, infection, delayed wound healing, and persistent postoperative pain compared with nonsmokers (50). Furthermore, increased rates of wound complications and infection have been associated with smoking in patients after ORIF of calcaneal fractures (51) and ankle fractures (52,53). Greater nonunion rates in smokers were also observed after subtalar arthrodesis (54).

What might be less certain is the effect of preoperative smoking reduction or cessation on surgical outcomes. A study evaluating patients undergoing general surgery and total joint arthroplasty demonstrated that smoking cessation 4 weeks before surgery and extending for 4 weeks after surgery resulted in an overall decrease in complications by 20% (55). Another study evaluating patients undergoing hip and knee arthroplasty revealed a decrease in all postoperative complications by 34% and a decrease in wound-related complications by 26% after a 6- to 8-week preoperative smoking cessation protocol (56). In an investigation evaluating incisional healing after cutaneous biopsy, smoking cessation 4 weeks before the procedure significantly decreased the rate of infection (57). That study also suggested that the duration of smoking cessation of 4, 8, or 12 weeks did not show any significant difference in terms of the occurrence of postoperative infection. Additionally, a study of colorectal patients showed no effect on the postoperative complication rate when the smoking cessation programs were initiated <4 weeks in advance (58).

We concluded that substantial evidence exists that cigarette smoking is associated with postoperative complications after foot and ankle surgery and that, as a profession, we should relay these risks to our patients. A survey of the British Orthopaedic Foot and Ankle Society revealed that only 9% of surgeons documented the smoking habits of their patients on consent forms and warned them of the risk of potential complications and only 23% reported taking any preventative perioperative measures (59). Although we cannot conclude that a smoking history is an absolute contraindication to a specific foot and ankle surgery, our consensus is that tobacco use should be considered a relative risk factor for the development of complications. Patients should be educated regarding the specific risks of tobacco use, and, when possible, smoking should be stopped at least several weeks before the performance of elective foot and ankle surgical procedures.

***Consensus statement*: The panel reached consensus that the statement "Elevated body mass index should be considered a risk factor for the development of complications after foot and ankle surgical procedures" was <u>neither appropriate nor inappropriate</u>.**

Obesity has been described as a global epidemic, and its effect on the development of some foot and ankle pathologic features is well established (60–72). However, the specific effect of obesity on complications after foot and ankle surgical procedures is less certain. We identified little evidence of an absolute contraindication to foot and ankle surgery in the setting of patient obesity or a BMI threshold over which specific foot and ankle surgical procedures should not be performed. However, the conclusion of our panel was that the presence of an elevated preoperative BMI is likely to carry at least some degree of risk for the development of some postoperative complications, including a thrombotic event, postoperative infection, and postoperative wound healing complications. This increased risk should be recognized and appreciated by both the surgeon and the patient.

Although many investigations have evaluated the association of BMI and surgical complications in their secondary analyses (51,73–84), we identified 20 studies with hypotheses specifically addressing the effect of obesity on lower extremity surgery (85–104). These included studies on total ankle arthroplasty, pilon fracture ORIF, ankle fracture ORIF, calcaneal fracture ORIF, ankle arthrodesis, Achilles tendon repair, ankle arthroscopy, flatfoot reconstruction, and elective forefoot reconstruction. Interestingly, 9 of these studies showed an association of obesity with the development of postoperative complications, including postoperative wound complication, postoperative infection, the need for revision surgery, the loss of articular reduction, an increased operative time, longer healing times, implant failure, decreased implant survival, venous thromboembolism, an increased length of stay, and general medical complications (including pulmonary embolism, myocardial infarction, respiratory failure, cerebral vascular event, pneumonia, acute renal failure, cholecystitis) (85–93), but the remaining 11 investigations did not show such an association (94–104).

Several of these studies involved database analyses with relatively large cohorts, and we observed that those larger studies tended to show the development of postoperative complications in the obese. Burrus et al (87) reviewed 18,948 patients undergoing Achilles tendon repair. Of those, 2962 were obese. The study found a greater rate of postoperative wound complication, postoperative infection, and other medical complications in the obese group. Werner et al (89) reviewed 23,029 patients undergoing total ankle arthroplasty or ankle arthrodesis and found that obese patients were more likely to experience postoperative infection, postoperative stiffness, and a range of medical complications. Bostman et al (93) found that a greater BMI was associated with a loss of reduction requiring reoperation in 3061 patients undergoing ankle ORIF. Chen et al (88) observed that obese patients were more likely to require revision hallux abductovalgus surgery in a series of 452 participants. In contrast, however, Stewart et al (94) found no difference in outcomes associated with obesity in a series of 633 forefoot surgeries.

This is an area in which our profession will likely learn more in the future and appears to be of contemporary interest to investigators, because most studies we identified specifically examining the effect of obesity on surgical outcomes have been published within the past 5 years. We also believe that it is important to note that although it is possible that obesity has a direct effect on surgical outcomes, it is also possible that obesity simply serves as a surrogate for other confounding factors.

***Consensus statement*: The panel reached consensus that the statement "An elevated glycated hemoglobin should be considered an independent risk factor for the development of complications after foot and ankle surgical procedures" was <u>appropriate</u>.**

The association between hyperglycemia and postoperative complications has been well documented after many types of surgical procedures (105–115). Poor long-term glucose control, as measured by glycated hemoglobin, has been recognized as a risk factor for the development of adverse outcomes after major surgeries, such as vascular and coronary artery procedures (105,106,109,114). In the foot and ankle specifically, poorly controlled and complicated diabetes has also been shown to be significant risk factors for both postoperative soft tissue and bone healing complications (112–114,116–121). Surgeons should be aware of this when recommending and performing foot and ankle surgery, and our patients should also be made aware that this increases the potential for postoperative complications. We also recommend that foot and ankle surgeons perform glycated hemoglobin measurement before performing elective surgery. It should be noted that this is in contrast to a random glucose measurement, which might be influenced by a variety of preoperative stresses and other factors.

Myers et al (116) have shown an association between an elevated glycated hemoglobin level and postoperative infection after hindfoot and/or ankle arthrodesis. Younger et al (120) also found that the most significant factor associated with successful transmetatarsal amputation in diabetic patients was blood glucose control measured by the glycated hemoglobin. They compared the mean glycated hemoglobin levels between a failed and successful group in their retrospective study of 42 patients. The mean level in the failed group was 10.6% and that of the successfully healed group was 7.8%. Lepore et al (122) evaluated patients admitted to the hospital for foot ulceration. In their cohort study, patients who had undergone major amputation, minor amputation, and no amputation were compared in terms of glycated hemoglobin level. They found that patients who had undergone amputation had a significantly greater glycated hemoglobin level than did those who had not undergone amputation. In particular, those who had undergone major amputation had a mean glycated hemoglobin level of 10% and those with minor amputation or no amputation had a mean glycated hemoglobin level of 9% and 8%, respectively. Humphers et al (123) investigated whether the glycated hemoglobin level was independently associated with postoperative complications in a retrospective cohort study. After adjusting for other covariates, they found that the glycated hemoglobin level was independently associated with postoperative soft tissue complication, including infection and wound dehiscence. Jupiter et al (124) assessed the relationship between the glycated hemoglobin levels and the rate of postoperative infection in the foot and ankle. They explored the general trends relating to the infection rates and preoperative glycated hemoglobin levels (124). Their preliminary analysis indicated that infection rates increased as the glycated hemoglobin level increased to 7.3% but increased rapidly with glycated hemoglobin values of 7.3% to 9.8% before leveling off.

The incidence of bone healing complications in diabetic patients is also high after foot and ankle surgeries (117,125–131). Although this association of hyperglycemia has been well documented (117,132–140), little clinical information is available regarding which diabetes-related comorbidities directly affect bone healing at a biochemical level. Shibuya et al (141) showed that approximately 1 of 4 diabetic patients had $\geq$1 bone healing complications. A bone healing complication was defined as $\geq$1 of nonunion, malunion, delayed union, or surgical- or trauma-induced Charcot neuroarthropathy. They found that a patient with a glycated hemoglobin level >7% had roughly 3 times greater odds of developing a bone healing complication than those with a glycated hemoglobin level <7%.

Most often in studies assessing the effect of long-term glycemic control on postoperative outcomes, the glycated hemoglobin level is used as the metric for control. Comparing well-controlled versus poorly controlled diabetics, many use a cutoff level of 7% to categorize good versus poor control, based on the American Diabetes Association recommendation. The American Diabetes Association recommendation is derived from several studies assessing intensive glycemic control therapy in reducing the long-term complications associated with diabetes, including the Diabetic Control and Complications Trial Research Group (DCCT), UK Prospective Diabetes Study (UKPDS), Action in Diabetes and Vascular Disease: Preterax and Diamicron Modified Release Controlled Evaluation (ADVANCE), Action to Control Cardiovascular Risk in Diabetes (ACCORD) trial, and Veterans Affairs Diabetes Trial (VADT) (142–147). Summarizing these findings, the benefits of lowering the glycated hemoglobin level in patients with diabetes in terms of the reduction of diabetes-related macro- and microvascular complications appear to be substantial. However, in decreasing the glycated hemoglobin level to <7%, the benefits seem to diminish, and a risk also exists of adverse events (including death, weight gain, and hypoglycemic episodes) in this range. It should also be noted that intensive glycemic control could be a risk itself, especially in a chronically uncontrolled diabetic patient population. Caution should be taken when attempting aggressive preoperative hyperglycemic control.

As recommended by many, including the American Diabetes Association, a glycated hemoglobin threshold of 7% is known to be a relatively good reference point, at least in terms of general health (148). However, definite evidence on foot and ankle-specific surgical procedures is still lacking. Furthermore, we believe it is important to note that an absolute threshold line might also depend on the type of procedure to be performed. Our panel concluded that elevated glycated hemoglobin values should be considered a risk factor for the development of complications after foot and ankle surgical procedures, that foot and ankle surgeons should check the glycated hemoglobin value before recommending and performing elective surgery in patients with diabetes, and that patients with an elevated glycated hemoglobin level should be made aware of their specific perioperative risks. However, we do not recommend a specific glycated hemoglobin threshold for the performance of elective foot and ankle surgical procedures.

***Consensus statement*: The panel reached consensus that the statement "A high preoperative blood glucose level should be considered a risk factor for the development of complications after foot and ankle surgical procedures" was neither appropriate nor inappropriate.**

Although exceedingly abnormal preoperative serum glucose levels are a general contraindication for elective surgery, little evidence is available to support that it has a consistent and direct effect on foot and ankle surgical outcomes. The reason that it might not be as robust a predictor as the glycated hemoglobin value might be because serum glucose levels can be affected by multiple factors, such as nil per os (or "nothing by mouth") status, surgical stress, and other day of surgery medications (149,150). It should also be noted that an attempt to rapidly decrease an elevated serum glucose level on the day of surgery could result in hypoglycemia and increased cardiovascular risk (151,152). In general, intensive glucose control and a low serum glucose level could be more harmful than a moderately elevated serum glucose level on the day of the surgery in diabetic patients (153–155).

We recognize that several studies have demonstrated an increased occurrence of SSIs associated with high preoperative serum glucose levels (111,156–158) but concluded that high serum glucose levels on the day of surgery might primarily be a confounder for poor long-term glycemic control. Therefore, one should understand that although the perioperative glucose level is unstable, sensitive, and easily affected by many factors on the day of surgery, it should primarily raise a concern regarding the patient's long-term glucose control and other underlying medical conditions. We identified no definitive evidence of a threshold value for the serum glucose level over which foot and ankle surgical procedures should not be performed.

Additionally, some emergency situations exist in which the risk of delaying surgery outweighs the risk of performing the operation with a high preoperative serum glucose level. In the management of abscess and cellulitis, for example, the elevated glucose level might be due to the infection itself; thus, the serum glucose level cannot be easily managed without surgical debridement, incision, and drainage. The anesthesia and surgical risks should be discussed among the surgical team in these situations.

***Consensus statement*: The panel was unable to reach consensus on the statement "Vitamin D levels should be assessed before all foot and ankle arthrodesis procedures."**

The panel was unable to reach consensus on the routine assessment of vitamin D levels before elective foot and ankle arthrodeses. The members of the panel who believed this was an inappropriate practice pointed to evidence demonstrating a high prevalence of hypovitaminosis D in acute fractures and other cohorts of otherwise "normal" individuals (159–163). Although the positive effects of vitamin D combined with calcium supplementation in fracture prevention in an elderly population has been well established (164–166), the effect of vitamin D on bone healing after injury or surgical intervention has not been as extensively studied. Although some studies have indicated a high incidence of vitamin D deficiency in patients with nonunion, these studies have often lacked a control group for comparison (162,167). Even less evidence is available to show that normalization of serum vitamin D in a deficient patient can assist in the prevention or treatment of nonunion. Therefore, it is uncertain whether a routine preoperative serum vitamin D evaluation is indicated before foot and ankle surgical procedures for assessment of bone healing potential and prevention of nonunion.

Further evidence has been provided by Haining et al (168), who compared the vitamin D levels in 15 patients with nonunion with 15 age- and gender-matched controls. The serum 25-hydroxyvitamin D, 1,25-dihydroxyvitamin D_3, and 24,25-dihydroxyvitamin D_3 levels were compared between these 2 groups (168). They did not show any difference in the vitamin D levels between the nonunion and the matched control groups (168). Boszczyk et al (169) conducted a case-controlled, cross-sectional study comparing the prevalence of vitamin D deficiency between patients with an idiopathic fracture healing impairment versus patients without such a complication. A total of 35 patients from each group were enrolled in their retrospective study. No differences were observed in the prevalence of vitamin D deficiency between the 2 groups. The overall prevalence of hypovitaminosis D was 86% in their cohort. Pourfeizi et al (170) compared the serum vitamin D levels in tibial nonunion cases and normal union cases. Their case-control study enrolled the control group from normal union patients matched by treatment type, age, gender, and BMI. They were considered vitamin D deficient when the serum 25-hydroxyvitamin D level was <23 nmol/L. They found that the prevalence of vitamin D deficiency was 30% in the matched control group and was 60% in the nonunion group. Ravindra et al (171) in their longitudinal study of 133 elective spinal fusions in the United States showed no association between vitamin D deficiency (serum 25-dihydroxyvitamin D level <20 ng/mL) and nonunion on bivariate analysis. However, it became an independent factor (odds ratio 3.5) for nonunion after adjusting for age, fusion length, and gender in a multiple regression analysis. In their cohort, 21 of the 133 patients (16%) were patients with nonunion. Nine of the 21 patients in this group had a vitamin D deficiency. They also showed that the median time to union was significantly longer in the vitamin D-deficient group on Kaplan-Meier survival analysis. Doetsch et al (172) in a randomized clinical trial examined the effect of vitamin D and calcium supplementation (oral 800 IU of vitamin D_3 and 1 g of calcium) on osteoporotic proximal humerus fracture healing. They found that the mineral density of the shoulder in the group with vitamin D and calcium supplementation was significantly greater statistically at 6 weeks. No difference was found at other time points (0, 2, and 12 weeks).

Because many patients in the control groups of these and other investigations have vitamin D deficiency, the incidence of this deficiency is also believed to be high in the normal population (173). Because of this, the results have been mixed in assessing the association of vitamin D deficiency and bone healing complications in the available case-control studies. Furthermore, no substantial evidence is available that supplementation of vitamin D positively affects bone healing after foot and ankle surgery. Further still, vitamin D deficiency is known to confound with many factors, such as older age, BMI, smoking, and heart and vascular diseases (162,173–175). The case-control studies accounted for some of these factors; however, it is difficult to control for all the variables without randomization.

The members of the panel who believed this was an appropriate practice argued that vitamin D deficiency could also affect aspects of postoperative outcomes other than bone healing (176–180). Warner et al (176) showed significantly lower clinical outcomes, as evidenced by the Foot and Ankle Outcome Score, after ORIF of ankle fractures in those patients with a preoperative vitamin D level <20 ng/mL. Lee et al (177) found that more patients experienced moderate to severe pain after knee arthroplasty when deficient in vitamin D.

Additionally, evidence has shown an association of vitamin D and bone healing in the published data (167,172,181–186). Vitamin D is crucial for ideal bone formation and metabolism and overall health (172,181,182). Vitamin D deficiency has been linked to several health issues, including cardiovascular disease, cancer, autoimmune diseases, diabetes mellitus, hypertension, and multiple sclerosis (186–188). In addition, vitamin D deficiency has been associated with specific bone metabolic diseases, including osteoporosis, osteomalacia, and poor bone growth. Vitamin D deficiency has also been cited as a common cause of stress fracture development and poor fracture healing (181,183,184).

During the past 2 decades, interest has been renewed in vitamin D and its role in bone and fracture healing, and it has been clearly established that the prevalence of hypovitaminosis D in the general population is high (167,185,189–191). The Centers for Disease Control and Prevention conducted a study identifying a prevalence rate of approximately 67% using a serum 25-hydroxyvitamin D concentration of <30 ng/mL as a threshold. Another study of young adults found a hypovitaminosis D prevalence rate of 51% (<30 ng/mL) (191). Several studies have evaluated vitamin D levels in patients undergoing orthopedic procedures. One study identified a vitamin D deficiency rate of 57% in patients who experienced nonunion after surgery (160). Smith et al (162) revealed a hypovitaminosis D prevalence rate of 47% in patients with low-energy ankle fractures.

Although we did not reach consensus that it is directly related to the postoperative outcome of foot and ankle arthrodeses, measurement of the preoperative vitamin D level might provide both the patient and the physician with an unrecognized component of the patient's overall health.

Direct Perioperative Considerations

***Consensus statement*: The panel reached consensus that the statement "Patients with open foot and ankle fractures should be treated with antibiotics" was <u>appropriate</u>.**

Our panel reached consensus that the immediate use of intravenous antibiotics, in conjunction with appropriate fracture debridement and stabilization, has been shown to be a primary key in reducing infection rates after lower extremity open fractures. This general treatment recommendation with respect to open fractures has been relatively unchanged since the 1970s, when Gustilo and Anderson (192) demonstrated greater rates of deep infection in grade 3 fractures when no antibiotics were used compared with those who received antibiotics. In the same decade, Patzakis et al (193) reported a significant infection rate of 14% in patients without antibiotic treatment versus 2.3% when intravenous antibiotics were used.

Most evidence and recommendations have pointed to the immediate initiation of intravenous antibiotics, with continuation extending approximately 48 to 72 hours after wound closure (194–199). In cases in which the wound cannot be closed primarily, the recommendation is to continue with intravenous antibiotics for 24 to 48 hours after eventual wound closure (194–196,199). The use of antibiotics for >72 hours after closure has not been found to provide additional benefit. In a study by Al-Arabi et al (200), the length of antibiotic therapy did not appear to have a significant effect on postoperative infection; rather, the fracture grade and degree of soft tissue injury were the most significant factors associated with the occurrence of infection. This finding has been supported by the results of other studies (195,201–203). Many contemporary studies have reported on the use of cefazolin for grade 1 and 2, with the addition of gentamicin for grade 3 open fractures (192,195,204–207).

***Consensus statement*: The panel reached consensus that the statement "The urgency of the treatment of open foot and ankle fractures is dependent on a variety of factors including, but not limited to, time, anatomic location, and fracture grade and extent" was <u>appropriate</u>.**

A review of the contemporary data indicated that most open foot and ankle fractures are likely not an emergent surgical situation but rather should be considered an urgent condition. A study by Skaggs et al (208) found that the rate of postoperative infection for pediatric patients undergoing debridement within 6 hours of the injury was 2.5%. However, patients who underwent debridement after 6 hours actually had a lower rate of infection at 1.6%, although this difference was not statistically significant (208). Another study by Harley et al (209) also failed to demonstrate that the time to debridement was a factor associated with development of a postoperative infection. The strongest predictors for deep infection in their study were fracture grade and lower extremity fracture location. The interval to formal debridement among the 215 patients in the study by Harley et al (209) ranged from 1 hour and 35 minutes to 30 hours and 40 minutes. Similar results of higher infection rates with lower extremity open fractures were observed by Malhotra et al (195) compared with upper extremity fractures. A similar study by Al-Arabi et al (200) noted that the only factor associated with incidence of postoperative infection was the fracture grade. Among their 237 patients, the infection rate was 7.8% for those who underwent debridement within 6 hours versus 9.6% if the debridement occurred after 6 hours. In 2008, Tripuraneni et al (210) showed similar infection rates, regardless of the interval to debridement. The patients who underwent debridement within 6 hours had an infection rate of 10.8%, and those who waited 6 to 12 hours before debridement had an infection rate of 9.5%. Counterintuitively, the patients who had undergone debridement

>12 hours after the injury had an even lower infection rate of 5.6%. The investigators concluded that in the absence of gross contamination, early informal irrigation should be performed on an urgent basis, along with the initiation of intravenous antibiotics, and that formal debridement can wait until later (210). Several studies have further supported the idea that the degree and severity of injury has a greater impact on postoperative infection development than the interval to formal debridement (195,202,206,211–214).

Our panel reached consensus that the treatment of open fractures in the foot and ankle always represents an urgent surgical matter but not necessarily an emergent one. We identified little clinical evidence in support of the so-called 6-hour "golden window." Certainly, open fractures warrant immediate antibiotic administration, bedside irrigation, and fracture stabilization; however, the timing of formal irrigation in an operating room might not have significant impact on the development of postoperative infections.

***Consensus statement*: The panel reached consensus that the statement "Perioperative management of diabetes medications warrants consideration before foot and ankle surgical procedures" was appropriate.**

The panel reached consensus that foot and ankle surgeons should consider and be cognizant of the medications prescribed for the treatment of diabetes mellitus in the perioperative period. However, the panel also concluded that this specific management was probably best deferred to the patient's primary care physician or endocrinologist when possible. Because patients with diabetes have an increased risk of morbidity and mortality during the perioperative period, maintaining appropriate glycemic control can minimize many of the consequences of hypoglycemia and hyperglycemia associated with surgery (149,151,215,216). The overall goal of the outpatient treatment of the diabetic patient should be focused on maintaining steady blood glucose levels and avoiding hypoglycemia, hyperglycemia, and other diabetes-related complications.

If lacking in specific consensus, some general themes were found in terms of the perioperative management of diabetes medications. Regarding insulin, the general recommendations include withholding short- or rapid-acting insulin and reducing intermediate- or long-acting basal insulin by 50% to 75% on the morning of surgery (148,149,151,215,217,218). Most oral glycemic agents such as thiazolidinediones and sulfonylureas can also be discontinued on the morning of surgery (149,217). Also, some have proposed withholding metformin 1 to 2 days before surgery owing to concerns of possible lactic acidosis (149,215,217). We found that evidence-based recommendations for the perioperative management of diabetic medications were somewhat limited (217–221).

***Consensus statement*: The panel reached consensus that the statement "Perioperative management of rheumatoid arthritis medications warrants consideration before foot and ankle surgical procedures" was appropriate.**

The panel reached consensus that foot and ankle surgeons should consider and be cognizant of the medications prescribed for the treatment of rheumatoid arthritis in the perioperative period but also concluded that this specific management was probably best deferred to the patient's primary care physician or rheumatologist when possible. The obvious concern is that the medications prescribed for the management of rheumatoid arthritis (including tumor necrosis factor [TNF]-α inhibitors, disease-modifying antirheumatic drugs, nonsteroidal anti-inflammatory drugs, and steroids) aim to suppress immune and inflammatory function and that this could result in an increased risk for the development of healing complications and postoperative infection.

Although many investigations have specifically examined foot and ankle surgery in the presence of rheumatoid arthritis, few have performed a comparative analysis or specifically examined the effect of perioperative medication management on patient outcomes (222–236). In 2003, Bibbo et al (222) retrospectively reviewed 725 foot and ankle procedures in 104 patients by dividing the cohort into those who had developed a postoperative complication ($n = 33$) and those who had not ($n = 71$). They observed no differences between the 2 groups with respect to medications. Bibbo and Goldberg (223) subsequently evaluated 2 groups of patients with rheumatoid arthritis undergoing elective foot and ankle surgery. One group was prescribed TNF-α inhibitor medications and continued these as originally prescribed throughout the perioperative course and another group did not receive TNF-α inhibitors (223). They observed no differences in healing or infectious complications between the 2 groups and concluded that these "agents may be safely administered in the perioperative period in the usual fashion" (223). Although 2 other studies identified delayed healing complications in 18% and 20.8% of rheumatoid arthritis patients undergoing forefoot surgery, this was only found to be associated with the duration of rheumatoid arthritis and longer operating times and not with medication use (224,225).

Several other review studies have addressed the need for stress dosing of prednisone and maintenance versus discontinuation of medications, including TNF-α inhibitors, disease-modifying antirheumatic drugs, nonsteroidal anti-inflammatory drugs, and steroids (237–243). Bibbo (237) has suggested a specific algorithm such that patients can continue regular dosing unless they have a documented history of wound healing complications, are undergoing surgery for an active infection, or develop an infection in the postoperative period. Our panel was in general agreement with these recommendations for most patients with rheumatoid arthritis.

***Consensus statement*: The panel reached consensus that the statement "Perioperative management of anticoagulation medications warrants consideration before foot and ankle surgical procedures" was appropriate.**

The panel reached consensus that foot and ankle surgeons should consider and be cognizant of anticoagulation medications in the perioperative period but also concluded that this specific management was probably best deferred to the patient's primary care physician, cardiologist, or vascular surgeon when possible. This includes management of both vitamin K antagonists and antiplatelet therapies.

The American College of Chest Physicians (ACCP) has published guidelines for the perioperative management of antithrombotic therapy, with the most recent edition published in 2012 (244). We recommend that foot and ankle surgeons familiarize themselves with these guidelines. We have provided a short summary of their recommendations. When considering elective outpatient foot and ankle surgical procedures, these guidelines recommend stopping vitamin K antagonists 5 days before surgery and resuming the antagonist 12 to 24 hours after surgery when hemostasis has been achieved. Bridging anticoagulation is recommended for patients at high risk of thromboembolism. This includes those with a mechanical heart valve, atrial fibrillation, or a history of venous thromboembolism. In patients with a relatively low risk of thromboembolism, bridging was not recommended. For patients taking aspirin and undergoing minor procedures, it was recommended that the aspirin should be continued around the time of surgery rather than discontinuing it for 7 to 10 days before the procedure. In patients with a coronary stent who require surgery, it is recommended that surgical intervention should be delayed 6 weeks after bare metal stent placement and 6 months after drug-eluting stent placement. If surgery is required during those periods, it is recommended that the antithrombotic therapy be continued through the surgery rather than stopping the therapy (244).

However, some recent investigations of which foot and ankle surgeons should be aware have challenged these guidelines. In a review of patients undergoing total knee and total hip arthroplasty, major surgical bleeding was noted in 12 of 13 patients who had received perioperative antithrombotic bridging (245). Of the bridging patients, 69% developed a hematoma (compared with only 10.2% of the control group). Also, 54% of the bridging patients required transfusion (compared with 8.3% of the control group) (245). Both of these differences were statistically significant. A second study evaluating total hip and knee arthroplasty patients revealed that patients who received anticoagulant bridging experienced a significantly greater bleeding-related complication rate and a significantly lower postoperative serum hemoglobin level compared with those who received prophylaxis (246). We identified no foot and ankle studies that evaluated perioperative complications secondary to the ACCP guidelines. We also could not identify studies that investigated the bleeding risk of foot and ankle surgery performed while maintaining antithrombotic therapy through the perioperative period.

***Consensus statement*: The panel reached consensus that the statement "Tourniquets can be safely used for most patients undergoing foot and ankle surgical procedures" was <u>appropriate</u>.**

A number of studies in the literature support the use of tourniquets in foot and ankle surgery, and our panel reached consensus that this is an appropriate practice for most patients. Surgeons should be aware, however, that although major adverse events are rare and the technique is generally considered to be safe (247–249), a few studies have noted increased postoperative pain and swelling in patients undergoing foot and ankle surgery with tourniquet use (250–252).

What might be a more clinically relevant discussion on this topic are the varying opinions on the appropriate tourniquet pressures used for foot and ankle surgery. Although we identified no comparative studies on different pressure levels, some interesting data are worth reviewing. Massey et al (253) have made recommendations for the appropriate tourniquet pressure using the mean arterial occlusion pressure. Using a handheld Doppler device, they determined that the average tourniquet pressure required to provide a bloodless field was 161.7 mm Hg for ankle tourniquets (253). In their study, the mean systolic pressure of the 50 healthy volunteers was 119.8 mm Hg (253). Thus, the investigators recommended that the lower extremity effective tourniquet pressure is approximately 230 to 250 mm Hg or 75 mm Hg greater than the systolic pressure. This might be in contrast to contemporary clinical practice. In a survey of 317 podiatric physicians, the most commonly used pressure was 301 to 350 mm Hg for the thigh and 201 to 250 mm Hg for the ankle and calf (254). Similar findings by the same group of investigators were reported in a survey sent to orthopedic physicians (255).

Another topic of potential debate is the concept of the "breathing period" with tourniquet use. We observed a lack of substantial evidence and considerable variance among the recommendations with respect to the ideal breathing period. For example, the recommendations for the breathing time ranged from a 30-minute interval after 2 hours of use, to a 10-minute deflation after 90 minutes of use, to 20 minutes after 1 hour of use, with upper limits of 3 hours (256–258). An animal study using rabbits reviewed the perfusion and degree of muscular ischemia after the prolonged use of tourniquets (259). Tourniquets were placed for 2 or 4 hours on the rabbit hind limbs, and the degree of skeletal muscle injury was identified using a technetium-99m scan. At 350 mm Hg of tourniquet pressure, muscle reperfusion was significantly reduced after 2 hours compared with 1 hour of cuff inflation.

In a study by Derner and Buckholz (260) using an ankle pressure of 325 mm Hg and thigh pressure of 400 mm Hg, 5 tourniquet-related postoperative complications were identified among 3027 patients. The investigators recommended deflating the tourniquet at 2 hours with a breathing time of 10 minutes (260). In another study by Reyes et al (248), 11% of 454 tourniquet cases exceeded 2 hours of total inflation time. The investigators reported no complications in these extended cases (248). Wakai et al (261) measured the creatine phosphokinase levels in patients undergoing surgery using an ankle tourniquet. The creatine phosphokinase levels did not increase after 1 hour of tourniquet use. Thus, they suggested limiting the ischemia time to 90 minutes, with a recommendation of 30 minutes of breathing time after 2 hours of tourniquet use (261). Given this variability, our panel did not reach consensus regarding breathing time intervals. This could represent an interesting avenue for future investigation within our profession.

We also recognize that some relative contraindications to tourniquet use exist. Some suggested contraindications include the presence of peripheral vascular disease, a prosthetic vascular graft or previous arterial bypass, extensive soft tissue injury, sickle cell disease, and a history of deep vein thrombosis (DVT) (254,255,257). However, few studies supporting such statements are available.

Most complications associated with the use of ankle or thigh tourniquets include postoperative pain and edema. A survey of foot and ankle surgeons reported complications such as strike-through bleeding or an inability to occlude at normal cuff pressures (39%), nerve injuries (28%), and skin injuries (26%) associated with ankle tourniquet use (254). Similar findings were reported in patients with thigh cuff use. Konrad et al (251) compared the complications observed in patients who had undergone an ankle fracture surgery with and without the use of a tourniquet. The investigators noted a greater postoperative complication rate among patients who had had a tourniquet used during their operation. Wound dehiscence (2 patients versus 1 patient), postoperative infection (2 patients versus 1 patient), and DVT (1 patient versus 0 patients) were seen more frequently in the group using tourniquets (251). Other listed, but not as well supported, complications include postoperative compression neuropraxia, hematoma, infection, compartment syndrome, thrombotic event, breakthrough bleeding, and skin injuries (262,263).

***Consensus statement*: The panel reached consensus that the statement "Prophylactic antibiotic therapy should be considered for foot and ankle surgical procedures" was <u>appropriate</u>.**

In 2015, the first ACFAS CCS addressed the topic of perioperative prophylactic antibiotic use in clean elective foot surgery (1). This CCS identified 6 investigations that produced original data on perioperative antibiosis in foot and ankle surgery (248,264–268) and relied heavily on 2 previously published guidelines by other medical societies (269,270). Although that panel generally produced consensus in favor of prophylactic preoperative antibiotic therapy in elective foot and ankle surgical procedures, they conceded that little to no empiric evidence was available in support of such practices. Their conclusion was that "the topic of prophylactic antibiotics in elective foot and ankle surgery is an unusual one, in that a relative divide exists between empirical science and common practice. Although there may not be a preponderance of evidence in support of this intervention, it is nevertheless widely used and, in fact, it is a requirement of most hospital systems. One way to view this is that physicians are routinely performing a relatively futile intervention that may be of little or no benefit to our patients. Another way to view it, however, is that this is an intervention without significant risk. The 6 studies specific to elective foot and ankle surgery that the panel identified as meeting our inclusion criteria did not demonstrate a significant benefit in terms of infection prophylaxis, but at the same time they did not result in the reporting of a single adverse event or complication from the intervention in more than 1000 patients studied" (1).

The present panel identified no other published studies directly evaluating prophylactic antibiosis in foot and ankle surgery and reached the same consensus. Despite a lack of objective evidence, given hospital regulations and common practice, we agree that it is not inappropriate to give preoperative antibiosis. This might be more appropriate in cases of longer duration and those involving the implementation of surgical hardware and less necessary (although not necessarily less appropriate) in cases not involving surgical hardware implementation.

Postoperative Considerations

***Consensus statement*: The panel reached consensus that the statement "Prophylactic postoperative antithrombotic therapy should be considered for some patients after foot and ankle surgical procedures" was <u>appropriate</u>.**

In 2015, a second ACFAS CCS addressed the topic of venous thromboembolism use in foot and ankle surgical procedures and in situations of prolonged immobilization (2). The panel suggested that the use of routine chemical prophylaxis in foot and ankle surgery is not justified. However, the panel also reported that use of chemical prophylaxis in foot and ankle surgery was appropriate in some situations depending on patient-specific risk factors. The factors they identified as resulting in the greatest risk included a personal history of venous thromboembolism, a history of malignancy, a hypercoagulable state, and situations of prolonged lower extremity immobilization. Other factors discussed in published studies that should be considered include a family history of thromboembolism, oral contraceptive use, hormone replacement therapy, advanced age, obesity, smoking, diabetes mellitus, and air travel (271–282). Our panel also concluded that although the routine use of pharmacologic prophylaxis is not necessary after foot and ankle surgery, the use of prophylaxis should be considered for some patients at high risk of venous thromboembolism development.

This is a challenging topic and one that remains of interest within the contemporary medical literature. As the risk of venous thromboembolism after major orthopedic surgery is well documented for patients undergoing procedures such as total joint arthroplasty and hip fracture, these patients are commonly treated with prophylactic antithrombotic therapy (283–289). However, the incidence of venous thromboembolism after foot and ankle surgery is relatively low. In a prospective multicenter study, Mizel et al (272) reported on 2733 patients after foot and ankle surgery and found an incidence of 0.22% for DVT and 0.15% for nonfatal pulmonary embolus (PE). In 2008, Wukich and Waters (271) reported an incidence rate of 0.4% for DVT and 0.3% for nonfatal PE in 1000 patients after foot and ankle surgery. Slaybaugh et al (273) in a retrospective review evaluated 1821 patients after foot and ankle surgery. The investigators demonstrated a 0.5% and 0.16% incidence rate for DVT and nonfatal PE, respectively (273).

In contrast, other studies have reported greater rates of venous thromboembolism after foot and ankle surgery, possibly related to patient-specific risk factors. A study by Solis and Saxby (274) involving 201 patients who underwent foot and ankle surgery found a prevalence of DVT of 3.5%. These investigators performed Doppler ultrasound examinations on the first postoperative visit of all patients, regardless of symptoms. Lassen et al (288), in a prospective, double-blind, placebo-controlled study, evaluated 440 patients who required immobilization after lower extremity fracture or Achilles tendon rupture. The incidence of DVT was found to be 19%. The investigators concluded that DVT is common with immobilization and that DVT prophylaxis is warranted and effective (288). In 2007, Lapidus et al (290) conducted a study of 105 foot and ankle surgery patients who had been surgically treated for Achilles tendon ruptures. They reported a DVT incidence of 36% (290).

In 2012, the ACCP published their most recent guidelines for the management of antithrombotic therapy in orthopedic surgery patients (291). In patients undergoing major orthopedic surgery, the ACCP recommends the administration of pharmacologic prophylaxis or an intermittent pneumatic compression device. In addition, the group suggested no pharmacologic prophylaxis for patients with isolated lower extremity injuries requiring immobilization. This is likely a topic and discussion that will continue to evolve as more evidence with respect to patient-specific factors is produced.

***Consensus statement*: The panel reached consensus that the statement "Foot and ankle surgeons should consider a multimodal approach to postoperative pain management" was <u>appropriate</u>.**

The appropriate use of pain management can affect the overall outcome after foot and ankle surgery, including improved recovery, a reduction in postoperative complications, and increased levels of patient satisfaction (291). Traditionally, pain control after surgery has been achieved with the use of opioid analgesics and other narcotics. However, these agents are clearly associated with several negative effects, including respiratory depression, sedation, nausea, vomiting, and physical dependence (292). In an effort to provide more effective pain relief and reduce the occurrence of these side effects, a multimodal approach to postoperative pain management has been widely advocated (293–295). The use of several analgesic techniques simultaneously might accomplish a synergistic effect and might provide more effective postoperative pain management compared with single-modality methods.

A substantial portion of the published orthopedic-related research on the multimodal approach to postoperative pain management has focused on total hip and knee arthroplasty (294–300), although some investigations have specifically studied the foot and ankle (301–305). Additionally, other clinical practice guidelines have discussed this topic in the general perioperative setting (306,307). Effective multimodal analgesic approaches for orthopedic surgery have included the use of opioids, nonsteroidal anti-inflammatory drugs, acetaminophen, alpha-2-delta ligands (i.e., gabapentin, pregabalin), regional anesthesia, peripheral nerve blocks, periarticular injections, and intra-articular infusions (294–300,302,303,305,306). Although many agree with respect to the use of a multimodal approach, little consensus has been reached with respect to which combination of specific interventions should be used for specific clinical situations.

Several broad considerations that foot and ankle surgeons should consider include preoperative education with respect to postoperative expectations (306,308), the preoperative administration of agents, including nonsteroidal anti-inflammatory drugs and alpha-2-delta ligands (301,304,307,309–314), and maximization of long-term agents with regional anesthesia (302,303,305,310,311).

Another challenging aspect of postoperative pain management is the duration of opioid use. Although this has been a topic of contemporary interest within the medical literature and national media, these concerns primarily relate to the long-term prescription of narcotics for chronic pain and not the treatment of acute postoperative pain (315–317). Most would consider that narcotic use should be short-term after acute surgical intervention, although no universal definition of "short term" has been identified. It is often difficult to balance this with patient expectations, and it is likely that it is a decision that should be made on an individual basis with clear open lines of physician–patient communication.

***Consensus statement*: The panel reached consensus that the statement "Foot and ankle surgical procedures involving arthrodesis of the first ray should use a period of non-weightbearing immobilization" was neither appropriate nor inappropriate.**

Arthrodesis procedures involving the first ray (first metatarsal–phalangeal joint and first metatarsal–medial cuneiform joint) have traditionally involved a period of postoperative non-weightbearing cast immobilization until some radiographic evidence of osseous consolidation has been observed at the fusion site (318–322). In addition to limiting the indication of these procedures to patients able to withstand this protocol, prolonged immobilization inherently has concerns for muscular atrophy and the development of venous thromboembolism. After a review of the contemporary data, our panel reached consensus that it is likely that early weightbearing can be allowed safely for some patients after these procedures.

With respect to first metatarsal–phalangeal joint arthrodesis, we identified a series of investigations that specifically evaluated some form of immediate or early weightbearing (323–331). Lampe et al (323) performed a prospective and randomized study of 61 participants undergoing first metatarsal–phalangeal joint arthrodesis with full weightbearing in a cast at 2 to 4 days versus non-weightbearing in a cast for 4 weeks. No differences in primary healing rates were observed. Storts and Camasta (324) completed a retrospective cohort study comparing buried Kirschner wire fixation and crossed screws, with both groups bearing immediate weight in a surgical shoe postoperatively. Although no comparative statistical analysis was performed, both groups demonstrated union rates >95%. We additionally identified 7 other retrospective case series of early weightbearing, with union rates ranging from 87.5% to 100.0% (325–331). We did not identify any study that concluded a negative effect of early weightbearing on outcomes after first metatarsal–phalangeal joint arthrodesis.

With respect to the first metatarsal–medial cuneiform joint arthrodesis, we identified a series of investigations that specifically incorporated early weightbearing into the study design (332–345). The reported arthrodesis union rates observed in these investigations ranged from 90.2% to 100.0%. Although most were case series, 3 studies implemented a comparative design. Prissel et al (332) performed a nonrandomized retrospective cohort analysis of >300 procedures comparing early (<21 days) and late (>21 days) weightbearing and did not observe a statistically significant difference in union rates. Basile et al (333) compared the arthrodesis performed with 2 crossed screws, an intermetatarsal pin, and immediate weightbearing (n = 24) to arthrodesis performed with 2 crossed screws and 4 to 6 weeks of non-weightbearing (n = 17) and found no nonunions or revision procedures in either group. Gutteck et al (334) prospectively grouped 34 patients into either immediate or delayed weightbearing and did not observe differences between the groups. Again, we did not identify any study that concluded a negative effect of early weightbearing on outcome after first metatarsal–medial cuneiform arthrodesis.

We think it is important to note, however, that these studies had some limitations for answering the question of early weightbearing. First, the studies varied substantially in terms of the fixation constructs used, the definition of "early weightbearing" (varying from immediately postoperative to up to several weeks), and the immobilization devices used (including surgical shoes, walking boots, and weightbearing casts). Second, little standardization was present in defining radiographic union. Finally, as a group, these studies were at risk of confirmation bias because most were retrospective case series performed by either a single surgeon or a small group of surgeons. Recognizing these limitations, we reached consensus that early weightbearing was not inappropriate and could be considered appropriate in some situations.

***Consensus statement*: The panel reached consensus that the statement "Foot and ankle surgeons should use routine postoperative radiographs in the absence of a clinical indication to assess osteotomy, fracture, and/or arthrodesis healing" was inappropriate.**

The panel reached consensus that it was inappropriate to use routine or serial postoperative radiographs in the absence of a specific clinical indication. This consensus does not refer to dedicated postoperative plain film radiographs and/or final intraoperative fluoroscopic imaging or radiographs taken at a postoperative clinical decision point (i.e., the initiation of weightbearing). It instead refers to radiographs performed without a specific indication and which are unlikely to result in a change in the treatment of a patient.

We identified several studies specific to the foot and ankle that provide evidence against routine postoperative radiographic assessment. Murphy and Blundell (346) performed a retrospective review of >250 consecutive scarf-type osteotomies for the surgical correction of the hallux abductovalgus deformity in which ≥1 "routine" postoperative radiograph was taken in the absence of a specific indication. A change in patient treatment occurred in only 2 of these cases—1 for broken fixation and 1 for recurrence. Several other investigators have studied the use of routine radiographs after ORIF of ankle fractures (347–350). Three studies with >500 ankles compared final intraoperative fluoroscopic images to either a dedicated postoperative plain film radiograph or a plain film radiograph on the first postoperative visit, and none resulted in a change in patient treatment (347–349). Similarly, McDonald et al (350) performed a retrospective review of 1411 ankle fractures comparing early (defined as 7 to 21 days) or late (defined as 22 to 120 days) initial postoperative radiographs. No differences were observed in the complication rates between the 2 groups.

These studies are consistent with other orthopedic studies examining routine postoperative radiographs after total knee arthroplasty, total hip arthroplasty, fixation of femur fractures, and spinal arthrodeses (351–359). We identified no study in the orthopedic literature that purported that the potential benefits of routine radiographic assessment in the absence of a specific clinical indication (i.e., identifying a complication that would result in a change in management) outweigh the risks (primarily cost and cumulative radiation exposure) (347,358–360).

We believe it is important to note that this consensus would not be expected to interfere with the requirements for foot and ankle surgery board certification. The American Board of Foot and Ankle Surgery requires "initial postoperative images" (defined as within 1 week of surgery and/or intraoperative images) and "final outcome images" (defined as ≥4 weeks postoperatively and demonstrating radiographic osseous union). Radiographs between these 2 time points are not specifically required (361).

***Consensus statement*: The panel reached consensus that the statement "Specific postoperative incisional care protocols should be used by foot and ankle surgeons" was neither appropriate nor inappropriate.**

Many potential benefits result from an appropriately applied postoperative surgical dressing, in particular, within the first 48 hours of the procedure (362,363). These include insulation and protection from outside debris, organisms, and temperature changes, absorption of excessive bleeding and drainage, compression against edema and hematoma formation, and minimization of pain, postoperative infection, and wound healing complications (364–367). With that said, however, evidence is lacking that any specific postoperative dressing protocol is superior to another when considering foot and ankle surgery (368). In contrast, in fact, it is likely that incisional care is multifaceted and decisions should be made based on a variety of factors, including the type of procedure, underlying medical conditions of the patient, postoperative follow-up and specific weightbearing protocols, the patient's home situation, and the use of adjunct modalities.

Underlying medical conditions that might affect dressing choices can include, but are not limited to, vascular diseases, coagulopathies, neuropathies, the use of tobacco products, allergies, and hypersensitivities. Adjunctive devices, such as drains, negative pressure-assisted wound dressings, cryotherapy, and gradual compression devices have been shown to be effective but can also alter the state of the surgical incision (369,370). A surgeon might therefore need to apply more or fewer compression or dressing materials or change the type of dressing, duration of coverage, and immobilization protocol depending on these medical and physical factors. Particular caution should be taken to protect the skin under a tube from a drain or negative pressure-assisted device, hard or sharp casting material, and excessive cold or heat. This is especially true when a patient has underlying neurovascular issues.

Postoperative compression might be clearly beneficial for hemostasis to reduce hematoma formation and blood loss and to reduce edema to control pain and wound healing (365,371–375). However, excessive compression can result in nerve palsy, blistering, pressure sore development, and even necrosis (366,376,377). Because the compression force is not easily measureable and the ideal force varies among individuals, a patient's feedback is important to avoid these complications. Similarly, the use of cryotherapy should be individualized because it depends on many medical and physical factors.

***Consensus statement*: The panel was <u>unable to reach consensus</u> on the statement "Foot and ankle surgeons should consider the use of bone stimulation in cases of delayed and nonunion."**

The panel was unable to reach consensus with respect to the relative appropriateness of bone stimulator use in cases of delayed and nonunion of the foot and ankle. Although it might be argued that little risk is associated with bone stimulator use (aside primarily from patient time and financial costs), contradictory evidence is available with respect to its efficacy in the foot and ankle for this indication. The group reached consensus that such treatment is not "inappropriate" but could not reach consensus on whether it was "appropriate" or "neither appropriate nor inappropriate." We concluded that the use of bone stimulators should likely be considered by foot and ankle surgeons for some, but not all, situations of delayed union and nonunion but that the specific indications are not currently evident to the point of consensus.

One of the complicating factors influencing this discussion is the inherent limitations of investigations into bone stimulator technology. It is rare that the bone stimulator is the only variable studied, and in fact, nearly always other confounding variables are present to consider. For example, we identified a small series of studies considering bone stimulator use with foot and ankle arthrodesis procedures (378–381). Jones et al (378) and Midis and Conti (379) implemented bone stimulator use in conjunction with revision arthrodesis surgery, but, of course, this also involved revision surgery. It would be difficult for these investigators to draw conclusions on the effect of the bone stimulator independent of the surgical procedure. Interestingly, Saltzman et al (380) reported on a series of 19 delayed foot and ankle arthrodeses initially treated with a pulsed electromagnetic field stimulator. Of these 19 patients, 5 healed with the stimulator use alone, but the others required revision surgery or refused further treatment.

Furthermore, even the original comparative studies of this technology comparing actual and sham units involved some form of immobilization and a component of time (382–390). This is a difficult topic as time also represents a confounding variable to consider because all fractures, osteotomies, and arthrodesis sites might be expected to demonstrate some progression toward healing given enough time with proper immobilization.

A Cochrane review was one of a number of reviews we identified that concluded the potential for, but less than definitive, beneficial effect (391–396). Griffen et al (391) specifically concluded with respect to delayed union or nonunion of long bone fractures that it "may offer some benefit….but is inconclusive and insufficient to inform clinical practice."

***Consensus statement*: The panel reached consensus that the statement "Foot and ankle surgeons should be aware of objective measures of patient satisfaction and postoperative outcome" was <u>appropriate</u>.**

Although the specifics might not as yet be clear, it is evident that US health care centers, hospitals, and third party payers are working toward value-based and outcome-based reimbursement strategies. We did not identify any investigation on this topic specific to the foot and ankle but did find a number of published reviews that have examined this as it relates to orthopedics and other surgery-based specialties (397–401). Walijee and Nellans (400) reported that with respect to extremity orthopedic surgery, this might be best thought of in terms of safety, outcomes, satisfaction, and cost. Of these, perhaps the most modifiable in terms of individual physicians and their practices are patient satisfaction and outcomes measurement. The strongest predictor of patient satisfaction has been identified as physician–patient communication; however, other important factors include the amount of time physicians spend with patients, patient waiting time for physicians, and physicians' ability to acknowledge risk and uncertainty with respect to patient care (400,402–404). Outcomes measurement might be relatively more difficult. Andrawis et al (401) criticized that orthopedic specialties lag behind other specialties on this topic because of a lack of accepted definitions, undefined indications for surgical intervention, and the use of too many outcome measures all evaluating similar factors. This is likely an area in which our national organizations can potentially work together toward standardization and physician education on a topic that is likely to affect the way we all practice during the coming decades. We reached consensus that it is appropriate for foot and ankle surgeons to at least begin to consider these measures within their practices.

References

1. Dayton P, DeVries JG, Landsman A, Meyr AJ, Schweinberger M. American College of Foot and Ankle Surgeons' clinical consensus statement: perioperative prophylactic antibiotic use in clean elective foot surgery. J Foot Ankle Surg 54:273–279, 2015.
2. Fleischer AE, Abicht BP, Baker JR, Boffeli TJ, Jupiter DC, Schade VL. American College of Foot and Ankle Surgeons' clinical consensus statement: risk, prevention, and diagnosis of venous thromboembolism disease in foot and ankle surgery and injuries requiring immobilization. J Foot Ankle Surg 54:497–507, 2015.
3. Smith GC, Pell JP. Parachute use to prevent death and major trauma related to gravitational challenge: systematic review of randomized controlled trials. BMJ 327:1459–1461, 2003.
4. Frykberg RG, Zgonis T, Armstrong DG, Driver VR, Giurini JM, Kravtiz SR, Landsman AS, Lavery LA, Moore JC, Schuberth JM, Wukich DK, Andersen C, Vanore JV; American College of Foot and Ankle Surgeons. Diabetic foot disorders: a clinical practice guideline (2006 revision). J Foot Ankle Surg 45(5 suppl):S1–S66, 2006.
5. Clinical Practice Guideline Forefoot Disorders Panel, Thomas JL, Blitch EL IV, Charney DM, Minucci KA, Eickmeier K, Rubin LG, Stapp MD, Vanore JV. Diagnosis and treatment of forefoot disorders. Section 1: digital deformities. J Foot Ankle Surg 49:418.e1–418.e9, 2009.

6. Clinical Practice Guideline Forefoot Disorders Panel, Thomas JL, Blitch EL IV, Charney DM, Minucci KA, Eickmeier K, Rubin LG, Stapp MD, Vanore JV. Diagnosis and treatment of forefoot disorders. Section 2. Central metatarsalgia. J Foot Ankle Surg 48:239–250, 2009.
7. Clinical Practice Guideline Forefoot Disorders Panel, Thomas JL, Blitch EL IV, Charney DM, Minucci KA, Eickmeier K, Rubin LG, Stapp MD, Vanore JV. Diagnosis and treatment of forefoot disorders. Section 3. Morton's intermetatarsal neuroma. J Foot Ankle Surg 48:251–256, 2009.
8. Clinical Practice Guideline Forefoot Disorders Panel, Thomas JL, Blitch EL IV, Charney DM, Minucci KA, Eickmeier K, Rubin LG, Stapp MD, Vanore JV. Diagnosis and treatment of forefoot disorders. Section 4. Tailor's bunion. J Foot Ankle Surg 48:257–263, 2009.
9. Clinical Practice Guideline Forefoot Disorders Panel, Thomas JL, Blitch EL IV, Charney DM, Minucci KA, Eickmeier K, Rubin LG, Stapp MD, Vanore JV. Diagnosis and treatment of forefoot disorders. Section 5. Trauma. J Foot Ankle Surg 48:264–272, 2009.
10. Thomas JL, Christensen JC, Kravitz SR, Mendicino RW, Schuberth JM, Vanore JV, Weil LS Sr, Zlotoff HJ, Bouche R, Baker J; American College of Foot and Ankle Surgeons Heel Pain Committee. The diagnosis and treatment of heel pain: a clinical practice guidelines-revision 2010. J Foot Ankle Surg 49(3 suppl):S1–S19, 2010.
11. Dalkey NC, Helmer O. An experimental application of the Delphi method to the use of experts. Manage Sci 9:458–468, 1963.
12. Park RE, Fink A, Brook RH, Chassin MR, Kahn KL, Merrick NJ, Kosecoff J, Solomon DH. Physician ratings of appropriate indications for six medical and surgical procedures. Am J Public Health 76:766–772, 1986.
13. Fleisher LA, Fleischmann KE, Auerbach AD, Barnason SA, Beckman JA, Bozkurt B, Davila-Roman VG, Gerhard-Herman MD, Holly TA, Kane GC, Marine JE, Nelson MT, Spencer CC, Thompson A, Ting HH, Uretsky BF, Wijeysundera DN. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: executive summary: a report of the American College of Cardiology/American Heart Association Task Force of practice guidelines. J Nucl Cardiol 22:162–215, 2015.
14. De Hert S, Imberger G, Carlisle J, Diemunsch P, Fritsch G, Moppett I, Solca M, Staender S, Wappler F, Smith A; Task Force on Preoperative Evaluation of the Adult Noncardiac Surgery Patient of the European Society of Anaesthesiology. Preoperative evaluation of the adult patient undergoing non-cardiac surgery: guidelines from the European Society of Anaesthesiology. Eur J Anaesthesiol 28:684–722, 2001.
15. Buckner TW, Leavitt AD, Ragni M, Kempton CL, Eyster ME, Cuker A, Lentz SR, Ducore J, Leissinger C, Wang M, Key NS. Prospective, multicenter study of postoperative deep-vein thrombosis in patients with haemophilia undergoing major orthopedic surgery. Thromb Haemost 116:42–49, 2016.
16. Fitz-Henry J. The ASA classification and peri-operative risk. Ann R Coll Surg Engl 93:185–187, 2011.
17. Vadivelu N, Gesquire M, Mitra S, Shelley K, Kodumudi G, Xia Y, Blume P. Safety of local anesthesia combined with monitored intravenous sedation for American Society of Anesthesiologists 3 and 4 patients undergoing lower limb-preservation procedures. J Foot Ankle Surg 49:152–154, 2010.
18. Bilimoria KY, Liu Y, Paruch JL, Zhou L, Kmiecik TE, Ko CY, Cohen ME. Development and evaluation of the universal ACS NSQIP surgical risk calculator: a decision aid and informed consent tool for patients and surgeons. J Am Coll Surg 217:833–842, 2013.
19. Ford MK, Beattie WS, Wijeysundera DN. Systematic review: prediction of perioperative cardiac complications and mortality by the revised cardiac risk index. Ann Intern Med 152:26–35, 2010.
20. Tanner J, Norrie P, Melen K. Preoperative hair removal to reduce surgical site infection. Cochrane Database Syst Rev 11:DC004122, 2011.
21. Lefebvre A, Saliou P, Lucet JC, Mimoz O, Keita-Perse O, Grandbastien B, Bruyere F, Boisrenoult P, Lepelletier D, Aho-Glele LS; French Study Group for the Preoperative Prevention of Surgical Site Infections. Preoperative hair removal and surgical site infections: network meta-analysis of randomized controlled trials. J Hosp Infect 91:100–108, 2015.
22. Adisa AO, Lawal OO, Adejuyigbe O. Evaluation of two methods of preoperative hair removal and their relationship to postoperative wound infection. J Infect Dev Ctries 5:717–722, 2011.
23. Leng P, Huang WL, He T, Wang YZ, Zhang HN. Outbreak of *Serratia marcescens* postoperative infection traced to barbers and razors. J Hosp Infect 89:46–50, 2015.
24. Ng AB, Adeyemo FO, Samarji R. Preoperative footbaths reduce bacterial colonization of the foot. Foot Ankle Int 30:860–864, 2009.
25. Webster J, Osborne S. Preoperative bathing or showering with skin antiseptics to prevent surgical site infection. Cochrane Database Syst Rev 20:CD004985, 2015.
26. Chlebicki MP, Safdar N, O'Horo JC, Maki DG. Preoperative chlorhexidine shower or bath for prevention of surgical site infection: a meta-analysis. Am J Infect Control 41:167–173, 2013.
27. Arciola CR, Cervellati M, Pirini V, Gamberini S, Montanaro L. Staphylococci in orthopaedic surgical wounds. New Microbiol 24:365–369, 2001.
28. Hidron AI, Edwards JR, Patel J, Horan TC, Sievert DM, Pollock DA, Fridkin SK; National Healthcare Safety Network Team; Participating National Healthcare Safety Network Facilities. NHSN annual update: antimicrobial-resistant pathogens associated with healthcare-associated infections: annual summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2006-2007. Infect Control Hosp Epidemiol 29:996–1011, 2008.
29. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Centers for Disease Control and Prevention (CDC) hospital infection control practices advisory committee. Am J Infect Control 27:97–132, 1999.
30. Kalra L, Camacho F, Whitener CJ, Du P, Miller M, Zalonis C, Julian KG. Risk of methicillin-resistant *Staphylococcus aureus* surgical site infection in patients with nasal MRSA colonization. Am J Infection Control 41:1253–1257, 2013.
31. Gupta K, Strymish J, Abi-Haidar Y, Williams SA, Itani KM. Preoperative nasal methicillin-resistant *Staphylococcus aureus* status, surgical prophylaxis and risk-adjusted postoperative outcomes in veterans. Infect Control Hosp Epidemiol 32:791–796, 2011.
32. Price CS, Williams A, Philips G, Dayton M, Smith W, Morgan S. *Staphylococcus aureus* nasal colonization in preoperative orthopaedic outpatients. Clin Orthop Relat Res 466:2842–2847, 2008.
33. Kim DH, Spencer M, Davidson SM, Li L, Shaw JD, Gulczynski D, Hunter DJ, Martha JF, Miley GB, Parazin SJ, Dejoie P, Richmond JC. Institutional prescreening for detection and eradication of methicillin-resistant *Staphylococcus aureus* in patients undergoing elective orthopedic surgery. J Bone J Surg Am 92:1820–1826, 2010.
34. Schweizer ML, Chiang HY, Septimus E, Moody J, Braun B, Hafner J, Ward MA, Hickok J, Perencevich EN, Diekema DJ, Richards CL, Cavanaugh JE, Perlin JB, Herwaldt LA. Association of a bundled intervention with surgical site infections among patients undergoing cardiac, hip or knee surgery. JAMA 313:2162–2171, 2015.
35. Hacek DM, Robb WJ, Paule SM, Kudrna JC, Stamos VP, Peterson LR. *Staphylococcus aureus* nasal decolonization in joint replacement surgery reduces infection. Clin Orthop Relat Res 466:1349–1355, 2008.
36. Chen AF, Heyl AE, Xu PZ, Rao N, Klatt BA. Preoperative decolonization effective at reducing staphylococcal colonization in total joint arthroplasty patients. J Arthroplasty 28(8 suppl):18–20, 2013.
37. Chen AF, Wessel CB, Rao N. Staphylococcus aureus screening and decolonization in orthopedic surgery and reduction of surgical site infection. Clin Orthop Relat Res 471:2383–2399, 2013.
38. Kalmeijer MD, van Nieuwland-Bollen E, Bogaers-Hofman D, de Baere GA. Nasal carriage of *Staphylococcus aureus* is a major risk factor for surgical site infections in orthopedic surgery. Infect Control Hosp Epidemiol 21:319–323, 2000.
39. Rao N, Cannella B, Crossett LS, Yates AJ Jr, McGough R III. A preoperative decolonization protocol for *Staphylococcus aureus* prevents orthopedic infections. Clin Orthop Relat Res 466:1343–1348, 2008.
40. Kallen AJ, Wilson CT, Larson RJ. Perioperative intranasal mupirocin for the prevention of surgical-site infections: systematic review of the literature and meta-analysis. Infect Control Hosp Epidemiol 26:916–922, 2005.
41. Economedes DM, Deirmengian GK, Deirmengian CA. *Staphylococcus aureus* colonization among arthroplasty patients previously treated by a decolonization protocol: a pilot study. Clin Orthop Relat Res 471:3128–3132, 2012.
42. Lee JJ, Patel R, Biermann JS, Dougherty PJ. The musculoskeletal effects of cigarette smoking. J Bone Joint Surg Am 95:850–859, 2013.
43. Lombardi AV Jr, Berend KR, Adams JB, Jefferson RC, Sneller MA. Smoking may be a harbinger of early failure with ultraporous metal acetabular reconstruction. Clin Orthop Relat Res 471:486–497, 2013.
44. Singh JA, Schleck C, Harmsen WS, Jacob AK, Warner DO, Lewallen DG. Current tobacco use is associated with higher rates of implant revision and deep infection after total hip or knee arthroplasty: a prospective cohort study. BMC Med 13:283, 2015.
45. Singh JA. Smoking and outcomes after knee and hip arthroplasty: a systematic review. J Rheumatol 38:1824–1834, 2011.
46. Manchio JV, Litchfield CR, Sati S, Bryan DJ, Weinzweig J, Vernadakis AJ. Duration of smoking cessation and its impact on skin flap survival. Plast Reconstr Surg 124:1105–1117, 2009.
47. Hirota Y, Hirohata T, Fukuda K, Mori M, Yanagawa H, Ohno Y, Sugioka Y. Association of alcohol intake, cigarette smoking, and occupational status with the risk of idiopathic osteonecrosis of the femoral head. Am J Epidemiol 137:530–538, 1993.
48. Musallam KM, Rosendaal FR, Zaatari G, Soweid A, Hoballah JJ, Sfeir PM, Zeineldine S, Tamim HM, Richards T, Spahn DR, Lotta LA, Peyvandi F, Jamali FR. Smoking and the risk of mortality and vascular and respiratory events in patients undergoing major surgery. JAMA Surg 148:755–762, 2013.
49. Krannitz KW, Fong HW, Fallat LM, Kish J. The effect of cigarette smoking on radiographic bone healing after elective foot surgery. J Foot Ankle Surg 48:525–527, 2009.
50. Bettin CC, Gower K, McCormick K, Wan JY, Ishikawa SN, Richardson DR, Murphy GA. Cigarette smoking increases complication rate in forefoot surgery. Foot Ankle Int 36:488–493, 2015.
51. Ding L, He Z, Xiao H, Chai L, Xue F. Risk factors for postoperative wound complications of calcaneal fractures following plate fixation. Foot Ankle Int 34:1238–1244, 2013.
52. Nasell H, Ottosson C, Tornqvist H, Linde J, Ponzer J. The impact of smoking on complications after operatively treated ankle fractures—a follow-up study of 906 patients. J Orthop Trauma 25:748–755, 2011.
53. Ovasaka MT, Makinen TJ, Madanat R, Vahlberg T, Hirvensalo E, Lindahl J. Predictors of poor outcomes following deep infection after internal fixation of ankle fractures. Injury 44:1002–1006, 2013.
54. Chahal J, Stephen DJ, Bulmer B, Daniels T, Kreder HJ. Factors associated with outcome after subtalar arthrodesis. J Orthop Trauma 20:555–561, 2006.
55. Lindström DL, Sadr Azodi OS, Wladis A, Tønnesen H, Linder S, Nåsell H, Ponzer S, Adami J. Effects of a perioperative smoking cessation intervention on postoperative complications: a randomized trial. Ann Surg 248:739–745, 2008.

56. Moller AM, Villebro N, Pedersen T, Tønnesen H. Effect of preoperative smoking intervention on postoperative complications: a randomised clinical trial. Lancet 359:114–117, 2002.
57. Sorensen LT. Wound healing and infection in surgery. The clinical impact of smoking and smoking cessation: a systemic review and meta-analysis. Arch Surg 147:373–383, 2012.
58. Sorensen LT, Jorgensen T. Short-term pre-operative smoking cessation intervention does not affect postoperative complications in colorectal surgery: a randomized clinical trial. Colorectal Dis 5:347–352, 2003.
59. Bhargava A, Greiss ME. Effects of smoking in foot and ankle surgery—an awareness survey of members of the British Orthopaedic Foot & Ankle Society. Foot 17:132–135, 2007.
60. Vela SA, Lavery LA, Armstrong DG, Anaim AA. The effect of increased weight on peak pressures: implications for obesity and diabetic foot pathology. J Foot Ankle Surg 37:416–420, 1998.
61. Sohn MW, Budiman-Mak E, Lee TA, Oh E, Stuck RM. Significant J-shaped association between body mass index (BMI) and diabetic foot ulcers. Diabetes Metab Res Rev 27:402–409, 2011.
62. Stuck RM, Sohn MW, Budiman-Mak E, Lee TA, Weiss KB. Charcot arthropathy risk elevation in the obese diabetic population. Am J Med 121:1008–1014, 2008.
63. Armstrong M. Obesity as an intrinsic factor affecting wound healing. J Wound Care 7:220–221, 1998.
64. Butterworth PA, Landorf KB, Smith SE, Menz HB. The association between body mass index and musculoskeletal foot disorders: a systematic review. Obes Rev 13:630–642, 2012.
65. Runhaar J, Koes BW, Clockaerts S, Bierma-Zeinstra SM. A systematic review on changed biomechanics of lower extremities in obese individuals: a possible role in development of osteoarthritis. Obes Rev 12:1071–1082, 2011.
66. Finkelstein EA, Chen H, Prabhu M, Trogdon JG, Corso PS. The relationship between obesity and injuries among U.S. adults. Am J Health Promot 21:460–468, 2007.
67. Wearing SC, Hennig EM, Byrne NM, Steele JR, Hills AP. Musculoskeletal disorders associated with obesity: a biomechanical perspective. Obes Rev 7:239–250, 2006.
68. Kessler J, Koebnick C, Smith N, Adams A. Childhood obesity is associated with increased risk of most lower extremity fractures. Clin Orthop Relat Res 471:1199–1207, 2013.
69. Chaudhry S, Egol KA. Ankle injuries and fractures in the obese patient. Orthop Clin North Am 42:45–53, 2011.
70. Moayyeri A, Luben RN, Wareham NJ, Khaw KT. Body fat mass is a predictor of risk of osteoporotic fracture in women but not in men: a prospective population study. J Intern Med 271:472–480, 2012.
71. Felcher AH, Mularski RA, Mosen DM, Kimes TM, DeLoughery TG, Laxson SE. Incidence and risk factors for venous thromboembolic disease in podiatric surgery. Chest 135:917–922, 2009.
72. Shibuya N, Frost CH, Campbell JD, Davis ML, Jupiter DC. Incidence of acute deep vein thrombosis and pulmonary embolism in foot and ankle trauma: analysis of the National Trauma Data Bank. J Foot Ankle Surg 51:63–68, 2012.
73. Japour C, Vohra P, Giorgini R, Sobel E. Ankle arthroscopy: follow-up study of 33 ankles—effect of physical therapy and obesity. J Foot Ankle Surg 35:199–209, 1996.
74. Basques BA, Miller CP, Golinvaux NS, Bohl DD, Grauer JN. Risk factors for thromboembolic events after surgery for ankle fractures. Am J Orthop (Belle Mead NJ) 44:E220–E224, 2015.
75. Belmont PJ Jr, Davey S, Rensing N, Bader JO, Waterman BR, Orr JD. Patient-based and surgical risk factors for 30-day postoperative complications and mortality after ankle fracture fixation. J Orthop Trauma 29:e476–e482, 2015.
76. Pakzad H, Thevendran G, Penner MJ, Qian H, Younger A. Factors associated with longer length of stay after primary elective ankle surgery for end-stage ankle arthritis. J Bone Joint Surg Am 96:32–39, 2014.
77. Morton TN, Zimmerman JP, Lee M, Schaber JD. A review of 105 consecutive uniport endoscopic plantar fascial release procedures for the treatment of chronic plantar fasciitis. J Foot Ankle Surg 52:48–52, 2013.
78. Pelet S, Roger ME, Belzile EL, Bouchard M. The incidence of thromboembolic events in surgically treated ankle fracture. J Bone Joint Surg Am 94:502–506, 2012.
79. Barg A, Henninger HB, Hintermann B. Risk factors for symptomatic deep vein thrombosis in patients after total ankle replacement who received routine chemical thromboprophylaxis. J Bone Joint Surg Br 93:921–927, 2011.
80. Miller AG, Marqules A, Raikin SM. Risk factors for incision-healing complications following total ankle arthroplasty. J Bone Joint Surg Am 94:2047–2052, 2012.
81. Still GP, Atwood TC. Operative outcome of 41 ankle fractures: a retrospective analysis. J Foot Ankle Surg 48:330–339, 2009.
82. Patel A, Ogawa B, Charlton T, Thordarson D. Incidence of deep vein thrombosis and pulmonary embolism after Achilles tendon rupture. Clin Orthop Relat Res 470:270–274, 2012.
83. Patton D, Kiewiet N, Brage M. Infected total ankle arthroplasty: risk factors and treatment options. Foot Ankle Int 36:626–634, 2015.
84. Noelle S, Egidy CC, Cross MB, Gebauer M, Klauser W. Complication rates after total ankle arthroplasty in one hundred consecutive prostheses. Int Orthop 37:1789–1794, 2013.
85. Cavo MJ, Fox JP, Markert R, Laughlin RT. Association between diabetes, obesity, and short-term outcomes among patients surgically treated for ankle fracture. J Bone Joint Surg Am 97:987–994, 2015.
86. Schipper ON, Denduluri SK, Zhou Y, Haddad SL. Effect of obesity on total ankle arthroplasty outcomes. Foot Ankle Int 37:1–7, 2016.
87. Burrus MT, Werner BC, Park JS, Perumal V, Cooper MT. Achilles tendon repair in obese patients is associated with increased complication rates. Foot Ankle Spec 9:208–214, 2016.
88. Chen JY, Lee MJ, Rikhraj, Parmar S, Chong HC, Yew AK, Koo KO, Singh Rikhray I. Effect of obesity on outcome of hallux valgus surgery. Foot Ankle Int 36:1078–1083, 2015.
89. Werner BC, Burrus MT, Looney AM, Park JS, Perumal V, Cooper MT. Obesity is associated with increased complications after operative management of end-stage arthritis. Foot Ankle Int 36:863–870, 2015.
90. Cecen GS, Gulabi D, Yanik E, Phelivanoglu G, Bekler H, Elmali N. Effect of BMI on the clinical and radiological outcomes of pilon fractures. Acta Orthop Traumatol Turc 48:570–575, 2014.
91. Mendelsohn ES, Hoshino CM, Harris TG, Zinar DM. The effect of obesity on early failure after operative syndesmosis injuries. J Orthop Trauma 27:201–206, 2013.
92. Abidi NA, Dhawan S, Gruen GS, Vogt MT, Conti SF. Wound-healing risk factors after open reduction and internal fixation of calcaneal fractures. Foot Ankle Int 19:856–861, 1998.
93. Bostman OM. Body-weight related to loss of reduction of fractures of the distal tibia and ankle. J Bone Joint Surg Br 77:101–103, 1995.
94. Stewart MS, Bettin CC, Ramsey MT, Ishikawa SN, Murphy GA, Richardson DR, Tolley EA. Effect of obesity on outcome of forefoot surgery. Foot Ankle Int 37:483–487, 2016.
95. Soukup DS, MacMahon A, Burket JC, Yu JM, Ellis SJ, Deland JT. Effect of obesity on clinical and radiographic outcomes following reconstruction of stage II adult acquired flatfoot deformity. Foot Ankle Int 37:245–254, 2016.
96. Gross CE, Lampley A, Green CL, DeOrio JK, Easley M, Adams S, Nunley JA II. The effect of obesity on function outcomes and complications in total ankle arthroplasty. Foot Ankle Int 37:137–141, 2016.
97. Bouchard M, Amin A, Pinsker E, Khan R, Deda E, Daniels TR. The impact of obesity on the outcome of total ankle replacement. J Bone Joint Surg Am 97:904–910, 2015.
98. Grodofsky SR, Sinha AC. The association of gender and body mass index with postoperative pain scores when undergoing ankle fracture surgery. J Anaesthesiol Clin Pharmacol 30:248–252, 2014.
99. Barg A, Knupp M, Anderson AE, Hintermann B. Total ankle replacement in obese patients: component stability, weight change and functional outcome in 118 consecutive patients. Foot Ankle Int 32:925–932, 2011.
100. Graves ML, Porter SE, Fagan BC, Brien GA, Lewis MW, Biggers MD, Woodall JR, Russel GV. Is obesity protective against wound healing complications in pilon surgery? Soft tissue envelope and pilon fractures in the obese. Orthopedics 33, 2010.
101. Baker JF, Perera A, Lui DF, Stephens MM. The effect of body mass index on outcomes after total ankle replacement. Irish Med J 102:188–190, 2009.
102. Strauss EJ, Frank JB, Walsh M, Koval KJ, Egol KA. Does obesity influence the outcome after the operative treatment of ankle fractures? J Bone Joint Surg Br 89:794–798, 2007.
103. Pinzur M, Freeland R, Juknelis D. The association between body mass index and foot disorders in diabetic patients. Foot Ankle Int 26:375–377, 2005.
104. Mardani-Kivi M, Mirbolook A, Karimi Mobarakeh M, Khajeh Jahromi S, Hassanzadeh R. Effect of obesity on arthroscopic treatment of anterolateral impingement syndrome of the ankle. J Foot Ankle Surg 54:13–16, 2015.
105. Acott AA, Theus SA, Kim LT. Long-term glucose control and risk of perioperative complications. Am J Surg 198:596–599, 2009.
106. Dronge AS, Perkal MF, Kancir S, Concato J, Aslan M, Rosenthal RA. Long-term glycemic control and postoperative infectious complications. Arch Surg 141:375–380, 2006.
107. Glassman SD, Alegre G, Carreon L, Dimar JR, Johnson JR. Perioperative complications of lumbar instrumentation and fusion in patients with diabetes mellitus. Spine J 3:496–501, 2003.
108. Golden SH, Peart-Vigilance C, Kao WH, Brancati FL. Perioperative glycemic control and the risk of infectious complications in a cohort of adults with diabetes. Diabetes Care 22:1408–1414, 1999.
109. Halkos ME, Puskas JD, Lattouf OM, Kilgo P, Kerendi F, Song HK, Guyton RA, Thourani VH. Elevated preoperative hemoglobin A1c level is predictive of adverse events after coronary artery bypass surgery. J Thorac Cardiovasc Surg 136:631–640, 2008.
110. Lamloum SM, Mobasher LA, Karar AH, Basiony L, Abdallah TH, Al-Saleh AI, Al-Shamali NA. Relationship between postoperative infectious complications and glycemic control for diabetic patients in an orthopedic hospital in Kuwait. Med Princ Pract 18:447–452, 2009.
111. Marchant MH Jr, Viens NA, Cook C, Vail TP, Bolognesi MP. The impact of glycemic control and diabetes mellitus on perioperative outcomes after total joint arthroplasty. J Bone Joint Surg Am 91:1621–1629, 2009.
112. Mraovic B, Suh D, Jacovides C, Parvizi J. Perioperative hyperglycemia and postoperative infection after lower limb arthroplasty. J Diabetes Sci Technol 5:412–418, 2011.
113. Noordzij PG, Boersma E, Schreiner F, Kertai MD, Feringa HH, Dunkelgrun M, Bax JJ, Klein J, Poldermans D. Increased preoperative glucose levels are associated with perioperative mortality in patients undergoing noncardiac, nonvascular surgery. Eur J Endocrinol 156:137–142, 2007.
114. O'Sullivan CJ, Hynes N, Mahendran B, Andrews EJ, Avalos G, Tawfik S, Lowery A, Sultan S. Haemoglobin A1c (HbA1C) in non-diabetic and diabetic vascular patients: is HbA1C an independent risk factor and predictor of adverse outcome? Eur J Vasc Endovasc Surg 32:188–197, 2006.

115. Richards JE, Kauffmann RM, Zuckerman SL, Obremskey WT, May AK. Relationship of hyperglycemia and surgical-site infection in orthopaedic surgery. J Bone Joint Surg Am 94:1181–1186, 2012.
116. Myers TG, Lowery NJ, Frykberg RG, Wukich DK. Ankle and hindfoot fusions: comparison of outcomes in patients with and without diabetes. Foot Ankle Int 33:20–28, 2012.
117. Perlman MH, Thordarson DB. Ankle fusion in a high risk population: an assessment of nonunion risk factors. Foot Ankle Int 20:491–496, 1999.
118. Wukich DK, Belczyk RJ, Burns PR, Frykberg RG. Complications encountered with circular ring fixation in persons with diabetes mellitus. Foot Ankle Int 29:994–1000, 2008.
119. Wukich DK, Shen JY, Ramirez CP, Irrgang JJ. Retrograde ankle arthrodesis using an intramedullary nail: a comparison of patients with and without diabetes mellitus. J Foot Ankle Surg 50:299–306, 2011.
120. Younger AS, Awwad MA, Kalla TP, de Vries G. Risk factors for failure of transmetatarsal amputation in diabetic patients: a cohort study. Foot Ankle Int 30:1177–1182, 2009.
121. Aragon-Sanchez J, Lazaro-Martinez JL. Impact of perioperative glycaemia and glycated haemoglobin on the outcomes of the surgical treatment of diabetic foot osteomyelitis. Diabetes Res Clin Pract 94:e83–e85, 2011.
122. Lepore G, Maglio ML, Cuni C, Dodesini AR, Nosari I, Minetti B, Trevisan R. Poor glucose control in the year before admission as a powerful predictor of amputation in hospitalized patients with diabetic foot ulceration. Diabetes Care 29:1985, 2006.
123. Humphers JM, Shibuya N, Fluhman BL, Jupiter D. The impact of glycosylated hemoglobin and diabetes mellitus on wound-healing complications and infection after foot and ankle surgery. J Am Podiatr Med Assoc 104:320–329, 2014.
124. Jupiter DC, Humphers JM, Shibuya N. Trends in postoperative infection rates and their relationship to glycosylated hemoglobin levels in diabetic patients undergoing foot and ankle surgery. J Foot Ankle Surg 53:307–311, 2014.
125. Bibbo C, Lin SS, Beam HA, Behrens FF. Complications of ankle fractures in diabetic patients. Orthop Clin North Am 32:113–133, 2001.
126. Blotter RH, Connolly E, Wasan A, Chapman MW. Acute complications in the operative treatment of isolated ankle fractures in patients with diabetes mellitus. Foot Ankle Int 20:687–694, 1999.
127. Connolly JF, Csencsitz TA. Limb threatening neuropathic complications from ankle fractures in patients with diabetes. Clin Orthop Relat Res 348:212–219, 1998.
128. Costigan W, Thordarson DB, Debnath UK. Operative management of ankle fractures in patients with diabetes mellitus. Foot Ankle Int 28:32–37, 2007.
129. Jones KB, Maiers-Yelden KA, Marsh JL, Zimmerman MB, Estin M, Saltzman CL. Ankle fractures in patients with diabetes mellitus. J Bone Joint Surg Br 87:489–495, 2005.
130. Kristiansen B. Ankle and foot fractures in diabetics provoking neuropathic joint changes. Acta Orthop Scand 51:975–979, 1980.
131. Prisk VR, Wukich DK. Ankle fractures in diabetics. Foot Ankle Clin 11:849–863, 2006.
132. Beam HA, Parsons JR, Lin SS. The effects of blood glucose control upon fracture healing in the BB Wistar rat with diabetes mellitus. J Orthop Res 20:1210–1216, 2002.
133. Follak N, Kloting L, Wolf E, Merk H. Delayed remodeling in the early period of fracture healing in spontaneously diabetic BB/OK rats depending on the diabetic metabolic state. Histol Histopathol 19:473–486, 2004.
134. Gandhi A, Beam HA, O'Connor JP, Parsons JR, Lin SS. The effects of local insulin delivery on diabetic fracture healing. Bone 37:482–490, 2005.
135. Kayal RA, Alblowi J, McKenzie E, Krothapalli N, Silkman L, Gerstenfeld L, Einhorn TA, Graves DT. Diabetes causes the accelerated loss of cartilage during fracture repair which is reversed by insulin treatment. Bone 44:357–363, 2009.
136. Kayal RA, Tsatsas D, Bauer MA, Allen B, Al-Sebaei MO, Kakar S, Leone CW, Morgan EF, Gerstenfeld LC, Einhorn TA, Graves DT. Diminished bone formation during diabetic fracture healing is related to the premature resorption of cartilage associated with increased osteoclast activity. J Bone Miner Res 22:560–568, 2007.
137. Lu H, Kraut D, Gerstenfeld LC, Graves DT. Diabetes interferes with the bone formation by affecting the expression of transcription factors that regulate osteoblast differentiation. Endocrinology 144:346–352, 2003.
138. Santana RB, Xu L, Chase HB, Amar S, Graves DT, Trackman PC. A role for advanced glycation end products in diminished bone healing in type 1 diabetes. Diabetes 52:1502–1510, 2003.
139. Tang SY, Vashishth D. Non-enzymatic glycation alters microdamage formation in human cancellous bone. Bone 46:148–154, 2010.
140. Mehta SK, Breitbart EA, Berberian WS, Liporace FA, Lin SS. Bone and wound healing in the diabetic patient. Foot Ankle Clin 15:411–437, 2010.
141. Shibuya N, Humphers JM, Fluhman BL, Jupiter DC. Factors associated with nonunion, delayed union, and malunion in foot and ankle surgery in diabetic patients. J Foot Ankle Surg 52:207–211, 2013.
142. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. The Diabetes Control and Complications Trial Research Group. N Engl J Med 329:977–986, 1993.
143. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). UK Prospective Diabetes Study (UKPDS) Group. Lancet 352:837–853, 1998.
144. Effect of intensive blood-glucose control with metformin on complications in overweight patients with type 2 diabetes (UKPDS 34). UK Prospective Diabetes Study (UKPDS) Group. Lancet 352:854–865, 1998.
145. ADVANCE Collaborative GroupPatel A, MacMahon S, Chalmers J, Neal B, Billot L, Woodward M, Marre M, Cooper M, Glasziou P, Grobbee D, Hamet P, Harrap S, Heller S, Liu L, Mancia G, Mogensen CE, Pan C, Poulter N, Rodgers A, Williams B, Bompoint S, de Galan BE, Joshi R, Travert F. Intensive blood glucose control and vascular outcomes in patients with type 2 diabetes. N Engl J Med 358:2560–2572, 2008.
146. Action to Control Cardiovascular Risk in Diabetes Study GroupGerstein HC, Miller ME, Byington RP, Goff DC Jr, Bigger JT, Buse JB, Cushman WC, Genuth S, Ismail-Beigi F, Grimm RH Jr, Probstfield JL, Simons-Morton DG, Friedewald WT. Effects of intensive glucose lowering in type 2 diabetes. N Engl J Med 358:2545–2559, 2008.
147. Duckworth W, Abraira C, Moritz T, Reda D, Emanuele N, Reaven PD, Zieve FJ, Marks J, Davis SN, Hayward R, Warren SR, Goldman S, McCarren M, Vitek ME, Henderson WG, Huang GD; VADT Investigators. Glucose control and vascular complications in veterans with type 2 diabetes. N Engl J Med 360:129–139, 2009.
148. American Diabetes Association. Standards of medical care in diabetes—2016. Diabetes Care 39(suppl 1):S1–S106, 2016.
149. Rizvi AA, Chillag SA, Chillag KJ. Perioperative management of diabetes and hyperglycemia in patients undergoing orthopaedic surgery. J Am Acad Orthop Surg 18:426–435, 2010.
150. Desborough JP. The stress response to trauma and surgery. Br J Anaesth 85:109–117, 2000.
151. Vann MA. Perioperative management of ambulatory surgical patients with diabetes mellitus. Curr Opin Anaesthesiol 22:718–724, 2009.
152. van Kuijk JP, Schouten O, Flu WJ, den Uil CA, Bax JJ, Poldermans D. Perioperative blood glucose monitoring and control in major vascular surgery patients. Eur J Vasc Endovasc Surg 38:627–634, 2009.
153. Duncan AE. Hyperglycemia and perioperative glucose management. Curr Pharm Des 18:6195–6203, 2012.
154. Sheehy AM, Gabbay RA. An overview of preoperative glucose evaluation, management, and perioperative impact. J Diabetes Sci Technol 3:1261–1269, 2009.
155. Drews HL III, Castiglione AL, Brentin SN, Ersig CR, Dukatz TK, Harrison BE, Omran FM, Rosenblatt SI. Perioperative hypoglycemia in patients with diabetes: incidence after low normal fasting preoperative blood glucose versus after hyperglycemia treated with insulin. AANA J 80(4 suppl):S17–S24, 2012.
156. Richards JE, Hutchinson J, Mukherjee K, Jahangir AA, Mir HR, Evans JM, Perdue AM, Obremskey WT, Sethi MK, May AK. Stress hyperglycemia and surgical site infection in stable nondiabetic adults with orthopedic injuries. J Trauma Acute Care Surg 76:1070–1075, 2014.
157. Sadoskas D, Suder NC, Wukich DK. Perioperative glycemic control and the effect on surgical site infections in diabetic patients undergoing foot and ankle surgery. Foot Ankle Spec 9:24–30, 2016.
158. Endara M, Masden D, Goldstein J, Gondek S, Steinberg J, Attinger C. The role of chronic and perioperative glucose management in high-risk surgical closures: a case for tighter glycemic control. Plast Reconstr Surg 132:996–1004, 2013.
159. Maier GS, Seeger JB, Horas K, Roth KE, Kurth AA, Maus U. The prevalence of vitamin D deficiency in patients with vertebral fragility fractures. Bone Joint J 97-B:89–93, 2015.
160. Bhattoa HP, Nagy E, More C, Kappelmayer J, Balogh A, Kalina E, Antal-Szalmas P. Prevalence and seasonal variation of hypovitaminosis D and its relationship to bone metabolism in healthy Hungarian men over 50 years of age: the HunMen Study. Osteoporos Int 24:179–186, 2013.
161. Dixon T, Mitchell P, Beringer T, Gallacher S, Moniz C, Patel S, Pearson G, Ryan P. An overview of the prevalence of 25-hydroxy-vitamin D inadequacy amongst elderly patients with or without fragility fracture in the United Kingdom. Curr Med Res Opin 22:405–415, 2006.
162. Smith JT, Halim K, Palms DA, Okike K, Bluman EM, Chiodo CP. Prevalence of vitamin D deficiency in patients with foot and ankle injuries. Foot Ankle Int 35:8–13, 2014.
163. Sprague S, Petrisor B, Scott T, Devji T, Phillips M, Spurr H, Bhandari M, Slobogean GP. What Is the role of vitamin D supplementation in acute fracture patients? A systematic review and meta-analysis of the prevalence of hypovitaminosis D and supplementation efficacy. J Orthop Trauma 30:53–63, 2016.
164. Avenell A, Mak JC, O'Connell D. Vitamin D and vitamin D analogues for preventing fractures in post-menopausal women and older men. Cochrane Database Syst Rev 4:CD000227, 2014.
165. Boonen S, Lips P, Bouillon R, Bischoff-Ferrari HA, Vanderschueren D, Haentjens P. Need for additional calcium to reduce the risk of hip fracture with vitamin D supplementation: evidence from a comparative metaanalysis of randomized controlled trials. J Clin Endocrinol Metab 92:1415–1423, 2007.
166. Bischoff-Ferrari HA, Willett WC, Wong JB, Giovannucci E, Dietrich T, Dawson-Hughes B. Fracture prevention with vitamin D supplementation: a meta-analysis of randomized controlled trials. JAMA 293:2257–2264, 2005.
167. Brinker MR, O'Connor DP, Monla YT, Earthman TP. Metabolic and endocrine abnormalities in patients with nonunions. J Orthop Trauma 21:557–570, 2007.
168. Haining SA, Atkins RM, Guilland-Cumming DF, Sharrard WJ, Russell RG, Kanis JA. Vitamin D metabolites in patients with established non-union of fracture. Bone Miner 1:205–209, 1986.
169. Boszczyk AM, Zakrzewski P, Pomianowski S. Vitamin D concentration in patients with normal and impaired bone union. Pol Orthop Traumatol 78:1–3, 2013.

170. Pourfeizi HH, Tabriz A, Elmi A, Aslani H. Prevalence of vitamin D deficiency and secondary hyperparathyroidism in nonunion of traumatic fractures. Acta Med Iran 51:705–710, 2013.
171. Ravindra VM, Godzik J, Dailey AT, Schmidt MH, Bisson MH, Hood RS, Cutler A, Ray WZ. Vitamin D levels and 1-year fusion outcomes in elective spine surgery: a prospective observational study. Spine (Phila Pa 1976) 40:1536–1541, 2015.
172. Doetsch AM, Faber J, Lynnerup N, Watjen I, Bliddal H, Danneskiold-Samsoe B. The effect of calcium and vitamin D3 supplementation on the healing of the proximal humerus fracture: a randomized placebo-controlled study. Calcif Tissue Int 75:183–188, 2004.
173. Robinson PJ, Bell RJ, Lanzafame A, Kirby C, Weekes A, Piterman L, Davis SR. The prevalence of vitamin D deficiency and relationship with fracture risk in older women presenting in Australian general practice. Australas J Ageing 32:177–183, 2013.
174. Sogomonian R, Alkhawam H, Jolly J, Vyas N, Ahmad S, Moradoghli Haftevani E, Al-Khazraji A, Finkielstein D, Vittorio TJ. Serum vitamin D levels correlate to coronary artery disease severity: a retrospective chart analysis. Expert Rev Cardiovasc Ther 14:977–982, 2016.
175. Syal SK, Kapoor A, Bhatia E, Sinha A, Kumar S, Tewari S, Garg N, Goel PK. Vitamin D deficiency, coronary artery disease, and endothelial dysfunction: observations from a coronary angiographic study in Indian patients. J Invasive Cardiol 24:385–389, 2012.
176. Warner SJ, Garner MR, Nguyen JT, Lorich DG. Perioperative vitamin D levels correlate with clinical outcomes after ankle fracture fixation. Arch Orthop Trauma Surg 136:339–344, 2016.
177. Lee A, Chan SK, Samy W, Chiu CH, Gin T. Effect of hypovitaminosis D on postoperative pain outcomes and short-term health-related quality of life after knee arthroplasty: a cohort study. Medicine (Baltimore) 94:e1812, 2015.
178. Laslett LL, Quinn S, Burgess JR, Parameswaran V, Winzenberg TM, Jones G, Ding C. Moderate vitamin D deficiency is associated with changes in knee and hip pain in older adults: a 5-year longitudinal study. Ann Rheum Dis 73:697–703, 2014.
179. Sriram K, Perumal K, Alemzadeh G, Osei A, Voronov G. The relationship between immediate preoperative serum 25-hydroxy-vitamin D(3) levels and cardiac function, dysglycemia, length of stay, and 30-d readmissions in cardiac surgery patients. Nutrition 31:820–826, 2015.
180. Amrein K, Schnedl C, Holl A, Riedl R, Christopher KB, Pachler C, Urbanic Purkart T, Waltensdorfer A, Munch A, Warnkross H, Stojakovic T, Bisping E, Toller W, Smolle KH, Berghold A, Pieber TR, Dobnig H. Effect of high-dose vitamin D3 on hospital length of stay in critically ill patients with vitamin D deficiency: the VITdAL-ICU randomized clinical trial. JAMA 312:1520–1530, 2014.
181. Eschle D, Aeschlimann AG. Is supplementation of vitamin D beneficial for fracture healing? A short review of the literature. Geriatr Orthop Surg Rehabil 2:90–93, 2011.
182. Guilsun K, Ki WO, Eun-Hee J, Mee-Kyoung K, Dong-Jun L, Hyuk SK, Ki-Hyun B, Kun-Ho Y, Won CL, Bong YC, Kwang-Woo L, Ho-Young S, Moo-Il K. Relationship between vitamin D, parathyroid hormone, and bone mineral density in elderly Koreans. J Korean Med Sci 27:636–643, 2012.
183. Holick MF. High prevalence of vitamin D inadequacy and implications for health. Mayo Clin Proc 81:353–373, 2006.
184. Kim TH, Yoon JY, Lee BH, Jung HS, Park MS, Park JO, Moon ES, Kim HS, Lee HM, Moon SH. Changes in vitamin D status after surgery in female patients with lumbar spinal stenosis and its clinical significance. Spine 37:E1326–E1330, 2012.
185. Rodriguez WJ, Gromelski J. Vitamin D status and spine surgery outcomes. ISRN Orthop 2013:1–12, 2013.
186. Thacher JG, Clarke BL. Vitamin D insufficiency. Mayo Clin Proc 86:50–60, 2011.
187. Holick MF. Sunlight and vitamin D for bone health and prevention of autoimmune diseases, cancers, and cardiovascular disease. Am Journal Clin Nutr 80:1678S–1688S, 2004.
188. Garland CF, French CB, Baggerly LL, Heaney RP. Vitamin D supplement doses and serum 25 hydroxyvitamin D in the range associated with cancer prevention. Anticancer Res 31:617–622, 2011.
189. Ginde AA, Liu MC, Camargo CA. Demographic trends and differences of vitamin D insufficiency in the US population, 1988-2004. Arch Intern Med 169:626–632, 2009.
190. Yetley EA. Assessing the vitamin D status of the US population. Am J Clin Nutr 88:558S–564S, 2008.
191. Binkley N, Novotny R, Krueger D, Kawahara T, Daida YG, Lensmeyer G, Hollis BW, Drezne MK. Low vitamin D status despite abundant sun exposure. J Clin Endocrinol Metab 92:2130–2135, 2007.
192. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. J Bone Joint Surg Am 58:453–458, 1976.
193. Patzakis MJ, Harvey JP Jr, Ivler D. The role of antibiotics in the management of open fractures. J Bone Joint Surg Am 56:532–541, 1974.
194. Patzakis MJ, Wilkins J, Moore TM. Use of antibiotics in open tibial fractures. Clin Orthop Relat Res 178:31–35, 1983.
195. Malhotra AK, Goldberg S, Graham J, Malhotra NR, Willis MC, Mounasamy V, Gilford K, Duane TM, Aboutanos MB, Mayglothling J, Ivatury RR. Open extremity fractures: impact of delay in operative debridement and irrigation. J Trauma Acute Care Surg 76:1201–1207, 2014.
196. Ovaska MT, Madanat R, Honkamaa M, Makinen TJ. Contemporary demographics and complications of patients treated for open ankle fractures. Injury 46:1650–1655, 2015.
197. Dellinger EP, Caplan ES, Weaver LD, Wertz MJ, Droppert BM, Hoyt N, Brumback R, Burgess A, Poka A, Benirschke SK, Lennard S, Lou MA. Duration of preventive antibiotic administration for open extremity fractures. Arch Surg 123:333–339, 1988.
198. Henley MB, Chapman JR, Agel J, Harvey EJ, Whorton AM, Swiontkowski MF. Treatment of type II, IIIA and III B open fractures of the tibial shaft: a prospective comparison of unreamed interlocking intramedullary nails and half-pin external fixators. J Orthop Trauma 12:1–7, 1998.
199. Hohmann E, Tetsworth K, Radziejowski MJ, Wiesniewski TF. Comparison of delayed and primary wound closure in the treatment of open tibial fractures. Arch Orthop Trauma Surg 127:131–136, 2007.
200. Al-Arabi YB, Nader M, Hamidian-Jahromi AR, Woods DA. The effect of the timing of antibiotics and surgical treatment on infection rates of open long- bone fracture: a 9-year prospective study from a district general hospital. Injury 38:900–905, 2007.
201. Dunkel N, Pittet D, Tovmirzaeva L, Suva D, Bernard L, Lew D, Hoffmeyer P, Uckay I. Short duration of antibiotic prophylaxis in open fractures does not enhance risk of subsequent infection. Bone Joint J 95-B:831–837, 2013.
202. Weber D, Dulai SK, Bergman J, Buckley R, Beaupre LA. Time to initial operative treatment following open fracture does not impact development of deep infection: a prospective cohort study of 736 subjects. J Orthop Trauma 28:613–619, 2014.
203. Hull PD, Johnson SC, Stephen DJ, Kreder HJ, Jenkinson RJ. Delayed debridement of severe open fractures is associated with a higher rate of deep infection. Bone Joint J 96-B:379–384, 2014.
204. Jenkinson RJ, Kiss A, Johnson S, Stephen DJ, Kreder HJ. Delayed wound closure increases deep-infection rate associated with lower-grade open fractures: a propensity-matched control study. J Bone Joint Surg Am 96:380–386, 2014.
205. Moola FO, Carli A, Berry GK, Reindl R, Jacks D, Harvey EJ. Attempting primary closure for all open fractures: the effectiveness of an institutional protocol. Can J Surg 57:E82–E88, 2014.
206. Moore TJ, Mauney C, Barron J. The use of quantitative bacterial counts in open fractures. Clin Orthop Relat Res 248:227–230, 1989.
207. Lenarz CJ, Watson JT, Moed BR, Israel H, Mullen JD, Macdonald JB. Timing of the wound closure in open fractures based on cultures obtained after debridement. J Bone Joint Surg Am 92:1921–1926, 2010.
208. Skaggs DL, Kautz SM, Kay RM, Tolo VT. Effect of delay of surgical treatment on rate of infection in open fractures in children. J Pediatr Orthop 20:19–22, 2000.
209. Harley BJ, Beaupre LA, Jones CA, Dulai SK, Weber DW. The effect of time to definitive treatment on the rate of nonunion and infection in open fractures. J Orthop Trauma 16:484–490, 2002.
210. Tripuraneni K, Ganga S, Quinn R, Gehlert R. The effect of time delay to surgical debridement of open tibia shaft fractures on infection rate. Orthopedics 31, 2008.
211. Spencer J, Smith A, Woods D. The effect of time delay on infection in open long-bone fractures: a 5-year prospective audit from a district general hospital. Ann R Coll Surg Engl 86:108–112, 2004.
212. Patzakis MJ, Wilkins J. Factors influencing infection rate in open fracture wounds. Clin Orthop Relat Res 243:36–40, 1989.
213. Skaggs DL, Friend L, Alman B, Chambers HG, Schmitz M, Leake B, Kay RM, Flynn JM. The effect of surgical delay on acute infection following 554 open fractures in children. J Bone J Surg Am 87:8–12, 2005.
214. Crowley DJ, Kanakaris NK, Giannoudis PV. Debridement and wound closure of open fractures: the impact of the time factor on infection rates. Injury 38:879–889, 2007.
215. Meneghini LF. Perioperative management of diabetes: translating evidence into practice. Cleve Clin J Med 76(suppl 4):S53–S59, 2009.
216. Garber AJ, Moghissi ES, Bransome ED Jr, Clark NG, Clement S, Cobin RH, Furnary AP, Hirsch IB, Levy P, Roberts R, Van den Berghe G, Zamudio V; American College on Endocrinology Task Force on Inpatient Diabetes Metabolic Control. American College of Endocrinology position statement on inpatient diabetes and metabolic control. Endocr Pract 10:77–82, 2004.
217. Hoogwerf BJ. Perioperative management of diabetes mellitus: how should we act on the limited evidence? Cleve Clin J Med 73(suppl):S95–S99, 2006.
218. DiNardo M, Donihi AC, Forte P, Gieraltowski L, Korytkowski M. Standardized glycemic management and perioperative glycemic outcomes in patients with diabetes mellitus who undergo same-day surgery. Endocr Pract 17:404–411, 2011.
219. Lipshutz AK, Gropper MA. Perioperative glycemic control: an evidence-based review. Anesthesiology 110:408–421, 2009.
220. Akhtar S, Barash PG, Inzucchi SE. Scientific principles and clinical implications of perioperative glucose regulation and control. Anesth Analg 110:478–497, 2010.
221. van den Berghe G, Wouters P, Weekers F, Verwaest C, Bruyninckx F, Schetz M, Vlasselaers D, Ferdinande P, Lauwers P, Bouillon R. Intensive insulin therapy in the critically ill patients. N Engl J Med 345:1359–1367, 2001.
222. Bibbo C, Anderson RB, Davis WH, Norton J. The influence of rheumatoid chemotherapy, age, and presence of rheumatoid nodules on postoperative complications in rheumatoid foot and ankle surgery: analysis of 725 procedures in 104 patients. Foot Ankle Int 24:40–44, 2003.
223. Bibbo C, Goldberg JW. Infectious and healing complications after elective orthopaedic foot and ankle surgery during tumor necrosis factor-alpha inhibition. Foot Ankle Int 25:331–335, 2004.
224. Ishie S, Ito H, Azukizawa M, Furu M, Ishikawa M, Ogino H, Hamamoto Y, Matsuda S. Delayed wound healing after forefoot surgery in patients with rheumatoid arthritis. Mod Rheumatol 25:367–372, 2015.

225. Yano K, Ikari K, Takatsuki Y, Taniguchi A, Yamanaka H, Momohara S. Longer operative time is the risk for delayed wound healing after forefoot surgery in patients with rheumatoid arthritis. Mod Rheumatol 26:211–215, 2016.
226. Cracchiolo A III, Cimino WR, Lian G. Arthrodesis of the ankle in patients who have rheumatoid arthritis. J Bone Joint Surg Am 74:903–909, 1992.
227. Reize P, Leichtle CI, Leichtle UG, Schanbacher J. Long-term results after metatarsal head resection in the treatment of rheumatoid arthritis. Foot Ankle Int 27:586–590, 2006.
228. Anderson T, Maxander P, Rydhom U, Besjakov J, Carlsson A. Ankle arthrodesis by compression screws in rheumatoid arthritis: primary nonunion in 9/35 patients. Acta Orthop 76:884–890, 2005.
229. Anderson T, Linder L, Rydholm U, Montgomery G, Besjakov J, Carlsson A. Tibiotalocalcaneal arthrodesis as a primary procedure using a retrograde intramedullary nail: a retrospective study of 26 patients with rheumatoid arthritis. Acta Orthop 76:580–587, 2005.
230. Nagashima M, Tachihara A, Matsuzaki T, Takenouchi K, Fujimori J, Yoshino S. Follow-up of ankle arthrodesis in severe hind foot deformity in patients with rheumatoid arthritis using an intramedullary nail with fins. Mod Rheumatol 15:269–274, 2005.
231. Scherrer CB, Mannion AF, Kyburz D, Vogt M, Kramers-de Quervain IA. Infection risk after orthopedic surgery in patients with inflammatory rheumatic diseases treated with immunosuppressive drugs. Arthritis Care Res 65:2032–2040, 2013.
232. Grennan DM, Gray J, Loudon J, Fear S. Methotrexate and early postoperative complications in patients with rheumatoid arthritis undergoing elective orthopedic surgery. Ann Rheum Dis 60:214–217, 2011.
233. Escalante A, Beardmore TD. Risk factors for early wound complications after orthopedic surgery for rheumatoid arthritis. J Rheumatol 22:1844–1851, 1995.
234. Fuerst M, Mohl H, Baumgartel K, Ruther W. Leflunomide increases the risk of early healing complications in patients with rheumatoid arthritis undergoing elective orthopedic surgery. Rheumatol Int 26:1138–1142, 2006.
235. Bridges SL Jr, Lopez-Mendez A, Han KH, Tracy IC, Alarcon GS. Should methotrexate be discontinued before elective orthopaedic surgery in patients with rheumatoid arthritis? J Rheumatol 18:984–988, 1991.
236. Carpenter MT, West SG, Vogelgesang SA, Casey Jones DE. Post-operative joint infections in rheumatoid arthritis patients on methotrexate therapy. Orthopaedics 19:207–210, 1996.
237. Bibbo C. Wound healing complications and infection following surgery for rheumatoid arthritis. Foot Ankle Clin 12:509–524, 2007.
238. Keith MP. Perspectives on rheumatoid arthritis for the orthopedic surgeon: overview of non-tumor necrosis factor biologic drugs and perioperative management. Am J Orthop (Belle Mead NJ) 40:E272–E275, 2011.
239. Haynie RL, Yakel J. Perioperative management of the rheumatoid patient. J Foot Ankle Surg 35:94–100, 1996.
240. MacKenzie CR, Sharrock NE. Perioperative medical considerations in patients with rheumatoid arthritis. Rheum Dis Clin North Am 24:1–17, 1998.
241. Neufeld JD, Weinraub GM, Hernandez ES, Co MS. The surgical reconstruction of rheumatoid midfoot and hindfoot deformities. Clin Podiatr Med Surg 27:261–273, 2010.
242. Nassar J, Cracchiolo A III. Complications in surgery of the foot and ankle in patients with rheumatoid arthritis. Clin Orthop Relat Res 391:140–152, 2001.
243. Reeves CL, Peaden AJ, Shane AM. The complications encountered with the rheumatoid surgical foot and ankle. Clin Podiatr Med Surg 27:313–325, 2010.
244. Douketis JD, Spyropoulos AC, Spencer FA, Mayr M, Jaffer AK, Eckman MH, Dunn AS, Kunz R; American College of Chest Physicians. Perioperative management of antithrombotic therapy: antithromboic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest 141(2 suppl):e326S–e350S, 2012.
245. Leijtens B, Kremers van de Hei K, Jansen J, Koeter S. High complication rate after total knee and hip replacement due to perioperative bridging of anticoagulant therapy based on the 2012 ACCP guideline. Arch Orthop Trauma Surg 134:1335–1341, 2014.
246. Haighton M, Kempen DH, Wolterbeek N, Marting LN, van Dijk M, Veen RM. Bridging therapy for oral anticoagulation increases the risk for bleeding-related complications in total joint arthroplasty. J Orthop Surg Res 10:145–152, 2015.
247. Tarver HA, Oliver SK, Ramming GJ, Englemann B. Techniques to maintain a bloodless field in lower extremity surgery. Orthop Nursing 19:65–73, 2000.
248. Reyes C, Barnauskas S, Hetherington V. Retrospective assessment of antibiotic and tourniquet use in an ambulatory surgery center. J Foot Ankle Surg 36:55–62, 1997.
249. Finsen V, Kasseth AM. Tourniquets in forefoot surgery: less pain when placed at the ankle. J Bone Joint Surg Br 79:99–101, 1997.
250. Rudkin AK, Rudkin GE, Dracopoulos DC. Acceptability of ankle tourniquet use in midfoot and forefoot surgery: audit of 1000 cases. Foot Ankle Int 25:788–794, 2004.
251. Konrad G, Markmiller M, Lenich A, Mayr E, Ruter A. Tourniquets may increase postoperative swelling and pain after internal fixation of ankle fractures. Clin Orthop Relat Res 433:189–194, 2005.
252. Kruse H, Christensen KP, Moller AM, Gogenur I. Tourniquet use during ankle surgery leads to increased postoperative opioid use. J Clin Anesth 27:380–384, 2015.
253. Massey KA, Blakeslee C, Martin W, Pitkow HS. Pneumatic ankle tourniquets: physiological factors related to minimal arterial occlusion pressure. J Foot Ankle Surg 38:256–263, 1999.
254. Kalla TP, Younger A, McEwen JA, Inkpen K. Survey of tourniquet use in podiatric surgery. J Foot Ankle Surg 42:68–76, 2003.
255. Younger A, Kalla TP, McEwen JA, Inkpen K. Survey of tourniquet use in orthopedic foot and ankle surgery. Foot Ankle Int 26:208–217, 2005.
256. Townsend HS, Goodman SB, Schurman DJ, Hackel A, Brock-Utne JG. Tourniquet release: systemic and metabolic effects. Acta Anesthesiol Scand 40:1234–1237, 1996.
257. Klenerman L. The tourniquet in surgery. J Bone Joint Surg Br 44-B:937–943, 1962.
258. Klenerman L, Biswas M, Hulands GH, Rhodes AM. Systemic and local effects of the application of a tourniquet. J Bone Joint Surg Br 62:385–388, 1980.
259. Pedowitz RA, Gershuni DH, Friden J, Garfin SR, Rydevik BL, Hargens AR. Effects of reperfusion intervals on skeletal muscle injury beneath and distal to a pneumatic tourniquet. J Hand Surg Am 17:245–255, 1992.
260. Derner R, Buckholz J. Surgical hemostasis by pneumatic ankle tourniquet during 3027 podiatric operations. J Foot Ankle Surg 34:236–246, 1995.
261. Wakai A, Winter DC, Street JT, Redmond PH. Pneumatic tourniquets in extremity surgery. J Am Acad Orthop Surg 9:345–351, 2001.
262. Simon MA, Mass DP, Zarins CK, Bidani N, Gudas CJ, Metz CE. The effect of a thigh tourniquet on the incidence of deep venous thrombosis after operations of the fore part of the foot. J Bone Joint Surg 64:188–191, 1982.
263. Smith TO, Hing CB. The efficacy of the tourniquet in foot and ankle surgery? A systematic review and meta-analysis. Foot Ankle Surg 16:3–8, 2010.
264. Zgonis T, Jolly GP, Garbalosa JC. The efficacy of prophylactic intravenous antibiotics in elective foot and ankle surgery. J Foot Ankle Surg 43:97–103, 2004.
265. Paiement GD, Renaud E, Dagenais G, Gosselin RA. Double-blind randomized prospective study of the efficacy of antibiotic prophylaxis for open reduction and internal fixation of closed ankle fractures. J Orthop Trauma 8:64–66, 1994.
266. Miller WA. Post-operative wound infection in foot and ankle surgery. Foot Ankle 4:102–104, 1983.
267. Akinyoola AL, Adegbehingbe OO, Odunsi A. Timing of antibiotic prophylaxis in tourniquet surgery. J Foot Ankle Surg 50:374–376, 2011.
268. Deacon JS, Wertheimer SJ, Washington JA. Antibiotic prophylaxis and tourniquet application in podiatric surgery. J Foot Ankle Surg 35:344–349, 1996.
269. Bratzler DW, Dellinger EP, Olsen KM, Perl TM, Auwaerter PG, Bolon MK, Fish DN, Napolitano LM, Sawyer RG, Slain D, Steinberg JP, Weinstein RA; American Society of Health-System Pharmacists; Infectious Disease Society of AmericaSurgical Infection SocietySociety for Healthcare Epidemiology of America. Clinical practice guidelines for antimicrobial prophylaxis in surgery. Am J Health Syst Pharm 70:195–283, 2013.
270. Dellinger EP, Gross PA, Barrett TL, Krause PJ, Martone WJ, McGowan JE Jr, Sweet RL, Wenzel RP. Quality standard for antimicrobial prophylaxis in surgical procedures. Infectious Disease Society of America. Clin Infect Dis 18:422–427, 1994.
271. Wukich D, Waters DH. Thromboembolism following foot and ankle surgery: a case series and literature review. J Foot Ankle Surg 47:243–249, 2008.
272. Mizel MS, Temple HT, Michelson JD, Alvarez RG, Clanton TO, Frey CC, Gegenheimer AP, Hurwitz SR, Lutter LD, Mankey MG, Mann RA, Miller RA, Richardson EG, Schon LC, Thompson FM, Yodlowski ML. Thromboembolism after foot and ankle surgery: a multicenter study. Clin Orthop Relat Res 348:180–185, 1998.
273. Slaybaugh RS, Beasley BD, Massa EG. Deep venous thrombosis risk assessment, incidence, and prophylaxis in foot and ankle surgery. Clin Podiatr Med Surg 20:269–289, 2003.
274. Solis G, Saxby T. Incidence of DVT following surgery of the foot and ankle. Foot Ankle Int 23:411–414, 2002.
275. Caprini JA. Thrombosis risk assessment as a guide to quality patient care. Dis Mon 51:70–78, 2005.
276. Edmonds MJ, Crichton TJ, Runciman WB, Pradhan M. Evidence-based risk factors for postoperative deep venous thrombosis. Anz J Surg 74:1082–1097, 2004.
277. Hanslow SS, Grujic L, Slater HK, Chen D. Thromboembolic disease after foot and ankle surgery. Foot Ankle Int 27:693–695, 2006.
278. Healy B, Beasley R, Weatherall M. Venous thromboembolism following prolonged cast immobilisation for injury to the tendo Achillis. J Bone Joint Surg Br 92:646–650, 2010.
279. Kadous A, Abdelgawad AA, Kanlic E. Deep venous thrombosis and pulmonary embolism after surgery treatment of ankle fractures: a case report and review of literature. J Foot Ankle Surg 51:457–463, 2012.
280. Makhdom AM, Cota A, Saran N, Chaytor R. Incidence of symptomatic deep venous thrombosis after Achilles tendon rupture. J Foot Ankle Surg 52:584–587, 2013.
281. Mayle RE, DiGiovanni CW, Lin SS, Tabrizi P, Chou LB. Current concepts review: venous thromboembolic disease in foot and ankle surgery. Foot Ankle Int 28:1207–1216, 2007.
282. Wolf JM, DiGiovanni CW. A surgery of orthopedic surgeons regarding DVT prophylaxis in foot and ankle trauma surgery. Orthopedics 27:504–508, 2004.
283. Eriksson BI, Kakar AK, Turpie AG, Gent M, Bandel TJ, Homering M, Misselwitz F, Lassen MR. Oral rivaroxaban for the prevention of symptomatic venous thromboembolism after elective hip and knee replacement. J Bone Joint Surg Br 91:636–644, 2009.
284. Falck-Ytter Y, Francis CW, Johanson NA, Curley C, Dahl OE, Schulman S, Ortel TL, Pauker SG, Colwell CW Jr; American College of Chest Physicians. Prevention of VTE in orthopedic surgery patients: antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest 141(2 suppl):e278S–e325S, 2012.

285. Huang J, Cao Y, Liao C, Wu L, Gao F. Apixaban versus enoxaparin in patients with total knee arthroplasty: a meta-analysis of randomized trials. Thromb Haemost 105:245–253, 2011.
286. Lassen MR, Gallus A, Raskob GE, Pineo G, Chen D, Ramirez LM; ADVANCE-3 Investigators. Apixaban versus enoxaparin for thromboprophylaxis after hip replacement. N Engl J Med 363:2487–2498, 2010.
287. Lassen MR, Davidson BL, Gallus A, Pineo G, Ansell J, Deitchman D. The efficacy and safety of apixaban, an oral, direct factor Xa inhibitor as thromboprophylaxis in patients following total knee replacement. J Thromb Haemost 5:2368–2375, 2007.
288. Lassen RM, Borris LC, Nakov RL. Use of low-molecular-weight heparin reviparin to prevent deep-vein thrombosis after leg injury requiring immobilization. N Eng J Med 347:726–730, 2002.
289. Turpie AG, Mauer KA, Eriksson BI, Lassen MR. Fondaparinux vs enoxaparin for the prevention of venous thromboembolism in major orthopedic surgery: meta-analysis of 4 randomized double-blind studies. Arch Intern Med 162:1833–1840, 2002.
290. Lapidus LJ, Rosfors S, Ponzer S, Levander C, Elvin A, Larfars G, deBri E. Prolonged thromboprophylaxis with dalteparin after surgical treatment of Achilles tendon rupture: a randomized, placebo-controlled study. J Orthop Trauma 21:52–57, 2007.
291. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. Br J Anaesth 78:606–617, 1997.
292. Wheeler M, Oderda GM, Ashburn MA, Lipman AG. Adverse events associated with postoperative opioid analgesia: a systematic review. J Pain 3:159–180, 2002.
293. Kehlet H, Dahl JB. The value of “multimodal” or “balanced analgesia” in postoperative pain treatment. Anesth Analg 77:1048–1056, 1993.
294. Vendittoli PA, Makinen P, Drolet P, Lavigne M, Fallaha M, Guertin MC, Varin F. A multimodal analgesia protocol for total knee arthroplasty: a randomized, controlled study. J Bone Joint Surg Am 88:282–289, 2006.
295. Hallivis R, Derksen TA, Meyr AJ. Peri-operative pain management. Clin Podiatr Med Surg 25:443–463, 2008.
296. Kang J, Ha YC, Kim JY, Woo YC, Lee JS, Jang EC. Effectiveness of multimodal pain management after bipolar hemiarthroplasty for hip fracture: a randomized, controlled study. J Bone Joint Surg Am 95:291–296, 2013.
297. Hojer Karlen AP, Geisler A, Petersen PL, Mathiesen O, Dahl JB. Postoperative pain treatment after total hip arthroplasty: a systemic review. Pain 156:8–30, 2015.
298. Krych AJ, Maran S, Kuzma SA, Smith HM, Johnson RL, Levy JA. Utility of multimodal analgesia with fascia iliaca blockade for acute pain management following hip arthroscopy. Knee Surg Sports Traumatol Arthrosc 22:843–847, 2014.
299. Lamplot JD, Wagner ER, Manning DW. Multimodal pain management in total knee arthroplasty: a prospective randomized controlled trial. J Arthroplasty 29:329–334, 2014.
300. Maheshwari AV, Blum YC, Shekhar L, Ranawat AS, Ranawat CS. Multimodal pain management after total hip and knee arthroplasty at the Ranawat Orthopedic Center. Clin Orthop Relat Res 467:1418–1423, 2009.
301. Brattwall M, Turan I, Jakobsson J. Pain management after elective hallux valgus surgery: a prospective randomized double-blind study comparing etoricoxib and tramadol. Anesth Analg 111:544–549, 2010.
302. Casati A, Fanelli G, Koscielniak-Nielsen Z, Cappelleri G, Aldegheri G, Danelli G, Fuzier R, Singelyn F. Using stimulating catheters for continuous sciatic nerve block shortens onset time of surgical block and minimizes postoperative consumption of pain medication after hallux valgus repair as compared with conventional nonstimulating catheters. Anesth Analg 101:1192–1197, 2005.
303. White PF, Issioui T, Skrivanek GD, Early JS, Wakefield C. The use of a continuous popliteal sciatic nerve block after surgery involving the foot and ankle: does it improve the quality of recovery? Anesth Analg 97:1303–1339, 2003.
304. YaDeau JT, Paroli L, Kahn RL, Jules-Elysee KM, LaSala VR, Liu SS, Lin E, Powell K, Buschiazzo VL, Wuovits B, Roberts MM, Levine DS. Addition of pregabalin to multimodal analgesic therapy following ankle surgery: a randomized double-blind placebo-controlled trial. Reg Anesth Pain Med 37:302–307, 2012.
305. Zaric D, Boysen K, Christiansen J, Haastrup U, Kofoed H, Rawal N. Continuous popliteal sciatic nerve block for outpatient for surgery—a randomized, controlled trial. Acta Anaesthesiol Scand 48:337–341, 2004.
306. Chou R, Gordon DB, de Leon-Casasola OA, Rosenberg JM, Bickler S, Brennan T, Carter T, Cassidy CL, Chittenden EH, Degenhardt E, Griffith S, Manworren R, McCarberg B, Montgomery R, Murphy J, Perkal MF, Suresh S, Sluka K, Strassels S, Thirlby R, Viscusi E, Walco GA, Warner L, Weisman SJ, Wu CL. Management of postoperative pain: a clinical practice guideline from the American Pain Society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists’ Committee on Regional Anesthesia, Executive Committee, and Administrative Council. J Pain 17:131–157, 2016.
307. American Society of Anesthesiologists Task Force on Acute Pain Management. Practice guidelines for acute pain management in the perioperative setting: an updated report by the American Society of Anesthesiologists Task Force on Acute Pain Management. Anesthesiology 116:248–273, 2012.
308. Kol E, Alpar SE, Erdogan A. Preoperative education and use of analgesic before onset of pain routinely for post-thoracotomy pain control can reduce pain effect and total amount of analgesics administered postoperatively. Pain Manag Nurs 15:331–339, 2014.
309. Gimbel JS, Brugger A, Zhao W, Verburg KM, Geis GS. Efficacy and tolerability of celecoxib versus hydrocodone/acetaminophen in the treatment of pain after ambulatory orthopedic surgery in adults. Clin Ther 23:228–241, 2001.
310. White PF. The role of non-opioid analgesic techniques in the management of pain after ambulatory surgery. Anesth Analg 94:577–585, 2002.
311. White PF. The changing role of non-opioid analgesic techniques in the management of postoperative pain. Anesth Analg 101(5 suppl):S5–S22, 2005.
312. Ekman EF, Wahba M, Ancona F. Analgesic efficacy of perioperative celecoxib in ambulatory arthroscopic knee surgery: a double-blind, placebo-controlled study. Arthroscopy 22:635–642, 2006.
313. Sawan H, Chen AF, Viscusi ER, Parvizi J, Hozack WJ. Pregabalin reduces opioid consumption and improves outcome in chronic pain patients undergoing total knee arthroplasty. Phys Sportsmed 42:10–18, 2014.
314. Zhang J, Ho KY, Wang Y. Efficacy of pregabalin in acute postoperative pain: a meta-analysis. Br J Anaesth 106:454–462, 2011.
315. Malay DS. Prescribing medications for pain relief: doctors, patients, and federal regulators. J Foot Ankle Surg 55:687, 2016.
316. Meyr AJ, Steinberg JS. Legal aspects of podiatric pain management. J Am Podiatr Med Assoc 100:511–517, 2010.
317. Chan KT, Fishman SM. Legal aspects of chronic opioid therapy. Curr Pain Headache Rep 10:426–430, 2006.
318. Rammelt S, Panzner I, Mittlmeier T. Metatarsophalangeal joint fusion: why and how? Foot Ankle Clin 20:465–477, 2015.
319. Wood EV, Walker CR, Hennessy MS. First metatarsophalangeal arthrodesis for hallux valgus. Foot Ankle Clin 19:245–258, 2014.
320. Little JB. First metatarsophalangeal joint arthrodesis in the treatment of hallux valgus. Clin Podiatr Med Surg 31:281–289, 2014.
321. Schmid T, Krause F. The modified Lapidus fusion. Foot Ankle Clin 19:223–233, 2014.
322. Baravarian B, Ben-Ad R. Contemporary approaches and advancements to the Lapidus procedure. Clin Podiatr Med Surg 31:299–308, 2014.
323. Lampe HI, Pontijne P, van Linge B. Weight bearing after arthrodesis of the first metatarsophalangeal joint: a randomized study of 61 cases. Acta Orthop Scand 62:544–555, 1991.
324. Storts EC, Camasta CA. Immediate weightbearing of first metatarsophalangeal joint fusion comparing buried crossed Kirschner wires versus crossed screws: does incorporating the sesamoid into the fusion contribute to higher incidence of bony union? J Foot Ankle Surg 55:562–566, 2016.
325. Roukis TS, Meusnier T, Augoyard M. Arthrodesis of the first metatarsal-phalangeal joint with flexible, ridged titanium intramedullary nails alone or supplemented with static staples and immediate weight-bearing: a consecutive series of 148 patients. Foot Ankle Spec 5:12–16, 2012.
326. Roukis TS, Meusnier T, Augoyard M. Nonunion rate of the first metatarsal-phalangeal joint arthrodesis for end-stage hallux rigidus with crossed titanium flexible intramedullary nails and a dorsal static staple with immediate weight-bearing. J Foot Ankle Surg 51:308–311, 2012.
327. Roukis TS, Meusnier T, Augoyard M. Nonunion rate of first metatarsal-phalangeal joint arthrodesis for end-stage hallux rigidus with cross titanium flexible intramedullary nails and dorsal static staple with immediate weight weight-bearing. J Foot Ankle Surg 51:191–194, 2012.
328. Roukis TS, Meusnier T, Augoyard M. Incidence of nonunion of first metatarsophalangeal joint arthrodesis for severe hallux valgus using crossed, flexible titanium intramedullary nails and a dorsal static staple with immediate weightbearing in female patients. J Foot Ankle Surg 51:433–436, 2012.
329. Mann JJ, Moon JL, Brosky TA II. Low-profile titanium plate construct for early weightbearing with first metatarsophalangeal joint arthrodesis. J Foot Ankle Surg 52:460–464, 2013.
330. Mah CD, Banks AS. Immediate weight bearing following first metatarsophalangeal joint fusion with Kirschner wire fixation. J Foot Ankle Surg 48:3–8, 2009.
331. Dayton P, McCall A. Early weightbearing after first metatarsophalangeal joint arthrodesis: a retrospective observational case analysis. J Foot Ankle Surg 43:156–159, 2004.
332. Prissel MA, Hyer CF, Grambart ST, Bussewitz BW, Brigido SA, DiDomenico LA, Lee MS, Reeves CL, Shand AM, Tucker DJ, Weinraub GM. A multicenter, retrospective study of early weightbearing for modified Lapidus arthrodesis. J Foot Ankle Surg 55:226–229, 2016.
333. Basile P, Cook EA, Cook JJ. Immediate weight bearing following modified Lapidus arthrodesis. J Foot Ankle Surg 49:459–464, 2010.
334. Gutteck N, Wohlrab D, Zeh A, Radetzki F, Delank KS, Lebek S. Comparative study of Lapidus bunionectomy using different osteosynthesis methods. Foot Ankle Surg 19:218–221, 2013.
335. Blitz NM, Lee T, Williams K, Barkan H, DiDimenico LA. Early weight bearing after modified Lapidus arthrodesis: a multicenter review of 80 cases. J Foot Ankle Surg 49:257–262, 2010.
336. Kazzaz S, Singh D. Postoperative cast necessity after a lapidus arthrodesis. Foot Ankle Int 30:746–751, 2009.
337. King CM, Richey J, Patel S, Collman DR. Modified Lapidus arthrodesis with cross screw fixation: early weightbearing in 136 patients. J Foot Ankle Surg 54:69–75, 2015.
338. Lamm BM, Wynes J. Immediate weightbearing after Lapidus arthrodesis with external fixation. J Foot Ankle Surg 53:577–583, 2014.
339. Sorensen MD, Hyer CF, Berlet GC. Results of Lapidus arthrodesis and locked plating with early weight bearing. Foot Ankle Spec 2:227–233, 2009.
340. Fuhrmann RA. Arthrodesis of the first tarsometatarsal joint for correction of the advanced splayfoot accompanied by hallux valgus. Oper Orthop Traumatol 17:195–210, 2005.

341. Cottom JM, Vora AM. Fixation of the Lapidus arthrodesis with a plantar interfragmentary screw and medial locking plate: a report of 88 cases. J Foot Ankle Surg 52:465–469, 2013.
342. Klos K, Wilde CH, Lange A, Wagner A, Gras F, Skulev HK, Muckley T, Simons P. Modified Lapidus arthrodesis with plantar plate and compression screw for treatment of hallux valgus with hypermobility of the first ray: a preliminary report. Foot Ankle Surg 19:239–244, 2013.
343. Faber F, Mulder PG, Verhaar JA. Role of first ray hypermobility in the outcome of the Hohmann and the Lapidus procedure: a prospective, randomized trial involving one hundred and one feet. J Bone Joint Surg Am 86:486–495, 2004.
344. Thompson IM, Bohay DR, Anderson JG. Fusion rate of first metatarsocuneiform arthrodesis in the modified Lapidus procedure and flatfoot reconstruction. Foot Ankle Int 26:698–703, 2005.
345. Bednarz P, Manoli A II. Modified Lapidus procedure for the treatment of hypermobile hallux valgus. Foot Ankle Int 21:816–821, 2000.
346. Murphy RJ, Blundell CM. Are routine postoperative x-rays needed following surgery for hallux valgus? An evaluation of their use after scarf osteotomy. Ann R Coll Surg Engl 89:281–284, 2007.
347. Miniaci-Coxhead SL, Martin EA, Ketz JP. Quality and utility of immediate formal postoperative radiographs in ankle fractures. Foot Ankle Int 36:1196–1201, 2015.
348. Ghattas TN, Dart BR, Pollock AG, Hinkin S, Pham A, Jones TL. Effect of initial postoperative visit radiographs on treatment plans. J Bone Joint Srg Am 95:e57, 2013.
349. Harish S, Vince AS, Patel AD. Routine radiography following ankle fracture fixation: a case for limiting its use. Injury 30:699–701, 1999.
350. McDonald MR, Bulka CM, Thakore RV, Obremskey WT, Ehrenfeld JM, Jahangir AA, Sethi MK. Ankle radiographs in the early postoperative period: do they matter? J Orthop Trauma 28:538–541, 2014.
351. Yamashita T, Steinmetz MP, Lieberman IH, Modic MT, Mroz TE. The utility of repeated postoperative radiographs after lumbar instrumented fusion for degenerative lumbar spine. Spine (Phila Pa 1976) 36:1955–1960, 2011.
352. Grimm BD, Leas DP, Glaser JA. The utility of routine postoperative radiographs after cervical spine fusion. Spine J 13:764–769, 2013.
353. Romero NC, Glaser J, Walton Z. Are routine radiographs needed in the first year after lumbar spinal fusions? Spine (Phila PA 1976) 34:1578–1580, 2009.
354. Ugokwe KT, Kalfas IH, Mroz TE, Steinmetz MP. Review of the utility of obtaining repeated postoperative radiographs following single-level anterior cervical decompression, fusion and plate placement. J Neurosurg Spine 9:175–179, 2008.
355. Christensen M, Folkmar K. No clinical value of post-operative routine X-ray following uncomplicated cementless primary total hip arthroplasty. Dan Med J 60:A4613, 2013.
356. Haddad FS, Williams RL, Prendergast CM. The check x-ray: an unnecessary investigation after hip fracture fixation. Injury 27:351–352, 1996.
357. Mohanty K, Gupta SK, Evans RM. Check radiography after fixation of hip fractures: is it necessary? J R Coll Surg Edinb 45:398–399, 2000.
358. Ververeli PA, Masonis JL, Booth RE, Hozack WJ, Rothman RH. Radiographic cost reduction strategy in total joint arthroplasty. J Arthroplasty 11:277–280, 1996.
359. Glaser D, Lotke P. Cost-effectiveness of immediate postoperative radiographs after un-complicated total knee arthroplasty: a retrospective and prospective study of 750 patients. J Arthroplasty 15:475–478, 2000.
360. Dyer O. Britain does too many x rays, says Audit Commission. BMJ 310:149, 1995.
361. ABFAS 220–2016 Document. Instructions for submitting case documentation. Available at: https://abfas.org/Portals/0/Documents/ABPS220.pdf. Accessed May 19, 2016.
362. Sticha RS, Swiriduk D, Wertheimer SJ. Prospective analysis of postoperative wound infections using an early exposure method of wound care. J Foot Ankle Surg 37:286–291, 1998.
363. Toon CD, Lusuku C, Ramamoorthy R, Davidson BR, Gurusamy KS. Early versus delayed dressing removal after primary closure of clean and clean-contaminated surgical wounds. Cochrane Database Syst Rev 9:CD010259, 2015.
364. Kottayasamy Seenivasagam R, Gupta V, Singh G. Prevention of seroma formation after axillary dissection—a comparative randomized clinical trial of three methods. Breast J 19:478–484, 2013.
365. Gottlieb T, Klaue K. The Jones dressing cast for safe aftercare of foot and ankle surgery: a modification of the Jones dressing bandage. Foot Ankle Surg 19:255–260, 2013.
366. Spanjersberg WR, Knops SP, Schep NW, van Lieshout EM, Patka P, Schipper IB. Effectiveness and complications of pelvic circumferential compression devices in patients with unstable pelvic fractures: a systematic review of literature. Injury 40:1031–1035, 2009.
367. Vaughan P, Haworth J, Humphrey J, Dega R. Optimal closure of surgical wounds in forefoot surgery: are adhesive strips beneficial? Acta Orthop Belg 72:731–733, 2006.
368. Dumville JC, Gray TA, Walter CJ, Sharp CA, Page T. Dressings for the prevention of surgical site infection. Cochrane Database Syst Rev 9:CD003091, 2014.
369. Matsumoto T, Parekh SG. Use of negative pressure wound therapy on closed surgical incision after total ankle arthroplasty. Foot Ankle Int 36:787–794, 2015.
370. Shibuya N, Schinke TL, Canales MB, Yu GV. Effect of cryotherapy devices in the postoperative setting. J Am Podiatr Med Assoc 97:439–446, 2007.
371. Ayhan H, Iyigun E, Ince S, Can MF, Hatipoglu S, Saglam M. A randomised clinical trial comparing the patient comfort and efficacy of three different graduated compression stockings in the prevention of postoperative deep vein thrombosis. J Clin Nurs 24:2247–2257, 2015.
372. Banerjee S, Kapadia BH, Issa K, McElroy MJ, Khanuja HS, Harwin SF, Mont MA. Postoperative blood loss prevention in total knee arthroplasty. J Knee Surg 26:395–400, 2013.
373. Gibbons CE, Solan MC, Ricketts DM, Patterson M. Cryotherapy compared with Robert Jones bandage after total knee replacement: a prospective randomized trial. Int Orthop 25:250–252, 2001.
374. Guzelkucuk U, Skempes D, Kumnerddee W. Common peroneal nerve palsy caused by compression stockings after surgery. Am J Phys Med Rehabil 93:609–611, 2014.
375. Pentikainen I, Piippo J, Ohtonen P, Junila J, Leppilahti J. Role of fixation and postoperative regimens in the long-term outcomes of distal chevron osteotomy: a randomized controlled two-by-two factorial trial of 100 patients. J Foot Ankle Surg 54:356–360, 2015.
376. Cheung A, Lykostratis H, Holloway I. Compression bandaging improves mobility following total knee replacement in an enhanced recovery setting. J Perioper Pract 24:84–86, 2014.
377. Eastburn S, Ousey K, Rippon MG. A review of blisters caused by wound dressing components: can they impede post-operative rehabilitation and discharge? Int J Orthop Trauma Nurs 21:3–10, 2016.
378. Jones CP, Coughlin MJ, Shurnas PS. Prospective CT scan evaluation of hindfoot nonunions treated with revision surgery and low-intensity ultrasound stimulation. Foot Ankle Int 27:229–235, 2006.
379. Midis N, Conti SF. Revision ankle arthrodesis. Foot Ankle Int 23:243–247, 2002.
380. Saltzman C, Lightfoot A, Amendola A. PEMF as treatment for delayed healing of foot and ankle arthrodesis. Foot Ankle Int 25:771–773, 2004.
381. Donley BG, Ward DM. Implantable electrical stimulation in high-risk hindfoot fusions. Foot Ankle Int 23:13–18, 2002.
382. Bassett CA, Mitchell SN, Gaston SR. Pulsing electromagnetic field treatment in ununited fractures and failed arthrodeses. JAMA 247:623–628, 1982.
383. Heckman JD, Ingram AJ, Loyd RD, Luck JV Jr, Mayer PW. Nonunion treatment with pulsed electromagnetic fields. Clin Orthop Relat Res 161:58–66, 1981.
384. Barker AT, Dixon RA, Sharrard WJ, Sutcliffe ML. Pulsed magnetic field therapy for tibial non-union: interim results of a double-blind trial. Lancet 1:994–996, 1984.
385. Sharrard WJ. A double-blind trial of pulsed electromagnetic fields for delayed union of tibial fractures. J Bone Joint Surg Br 72:347–355, 1990.
386. Scott G, King JB. A prospective, double-blind trial of electrical capacitive coupling in the treatment of non-union of long bones. J Bone Joint Surg Am 76:820–826, 1994.
387. Brighton CT, Shaman P, Heppenstall RB, Esterhai JL Jr, Pollack SR, Griedenberg ZB. Tibial non-union treated with direct current, capacitive coupling, or bone graft. Clin Orthop Relat Res 321:223–234, 1995.
388. Schofer MD, Block JE, Aigner J, Schmelz A. Improved healing response in delayed unions of the tibia with low-intensity pulsed ultrasound: results of a randomized sham-controlled trial. BMC Musculoskelet Disord 11:229, 2010.
389. Fox IM, Smith SD. Bioelectric repair of metatarsal nonunions. J Foot Surg 22:108–115, 1983.
390. Holmes GB Jr. Treatment of delayed unions and nonunions of the proximal fifth metatarsal with pulsed electromagnetic fields. Foot Ankle Int 15:552–556, 1994.
391. Griffen XL, Costa ML, Parsons N, Smith N. Electromagnetic field stimulation for treating delayed union or nonunion of long bone fractures in adults. Cochrane Database Syst Rev 12:CD008471, 2011.
392. Cook JJ, Summers NJ, Cook EA. Healing in the new millennium: bone stimulators: an overview of where we've been and where we may be heading. Clin Podiatr Med Surg 32:45–59, 2015.
393. Akai M, Hayashi K. Effect of electrical stimulation on musculoskeletal systems: a meta-analysis of controlled clinical trials. Bioelectromagnetics 23:132–143, 2002.
394. Kesani AK, Gandhi A, Lin SS. Electrical bone stimulation devises in foot and ankle surgery: types of devices, scientific basis, and clinical indications for their use. Foot Ankle Int 27:148–156, 2006.
395. Bassett CA. The development and application of pulsed electromagnetic fields (PEMFs) for ununited fractures and arthrodeses. Ortho Clin North Am 15:61–87, 1984.
396. Gossling HR, Bernstein RA, Abbott J. Treatment of ununited tibial fractures: a comparison of surgery and pulsed electromagnetic fields. Orthopedics 15:711–719, 1992.
397. Bosco JA III, Sachdev R, Shapiro LA, Stein SM, Zuckerman JD. Measuring quality in orthopaedic surgery: the use of metrics in quality management. Instr Course Lect 63:473–485, 2014.
398. Katz G, Ong C, Hutzler L, Zuckerman JD, Bosco JA III. Applying quality principles to orthopaedic surgery. Instr Course Lect 63:465–472, 2014.
399. Snyder CF, Aaronson NK. Use of patient-reported outcomes in clinical practice. Lancet 374:369–370, 2009.
400. Walijee JF, Nellans K. Quality assessment in hand surgery. Hand Clin 30:259–268, 2014.
401. Andrawis JP, Chenok KE, Bozic KJ. Health policy implications of outcomes measurement in orthopaedics. Clin Orthop Relat Res 471:3475–3481, 2013.
402. Chow A, Mayer EK, Darzi AW, Athanasiou T. Patient-reported outcome measures: the importance of patient satisfaction in surgery. Surgery 146:435–443, 2009.
403. Shirley ED, Sanders JO. Patient satisfaction: implications and predictors of success. J Bone Joint Surg Am 95:e69, 2013.
404. Jackson JL, Chamberlin J, Kroenke K. Predictors of patient satisfaction. Soc Sci Med 52:609–620, 2001.