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A Coding System for Reoperations Following Total Ankle Replacement and Ankle Arthrodesis

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Abstract

Background: Repeated surgery can be a measure of failure of the primary surgery. Future reoperations might be avoided if the cause is recognized and procedures or devices modified accordingly. Reoperations result in costs to both patient and the health care system. This paper proposes a new classification system for reoperations in end-stage ankle arthritis, and analyzes reoperation rates for ankle joint replacement and arthrodesis surgeries from a multicenter database.

Methods: A total of 213 ankle arthrodeses and 474 total ankle replacements were prospectively followed from 2002 to 2010. Reoperations were identified as part of the prospective cohort study. Operating reports were reviewed, and each reoperation was coded. To verify inter- and intraobserver reliability of this new coding system, 6 surgeons experienced in foot and ankle surgery were asked to assign a specific code to 62 blinded reoperations, on 2 separate occasions. Reliability was determined using intraclass correlation coefficients (ICCs) and proportions of agreement.

Results: Of a total of 687 procedures, 74.8% (514/687) required no reoperation (Code 1). By surgery type, 14.1% (30/213) of ankle arthrodesis procedures and 30.2% (143/474) of ankle replacement procedures required reoperation. The rate for reoperations surrounding the ankle joint (ie, Codes 2 and 3) was 9.9% (21/213) for ankle arthrodesis versus 5.9% for ankle replacement (28/474). Reoperation rates within the ankle joint (ie, Codes 4 to 10) were 4.7% (10/213) for ankle arthrodesis and 26.1% (124/474) for ankle replacement. Overall, 0.9% (2/213) of arthrodesis procedures required reoperation outside the initial operative site (Code 3), versus 4.6% (22/474) for total ankle replacement. The rate of reoperation due to deep infection (Code 7) was 0.9% (2/213) for arthrodesis versus 2.3% (11/474) for ankle replacement. Interobserver reliability testing produced a mean ICC of 0.89 on the first read. The mean ICC for intraobserver reliability was 0.92. For interobserver, there was 87.9% agreement (804/915) on the first read, and 87.5% agreement (801/915) on the second. For the intra observer readings, 88.5% (324/366) were in agreement.

Conclusions: The new coding system presented here was reliable and may provide a more standardized, clinically useful framework for assessing reoperation rates and resource utilization than prior complication- and diagnosis-based classification systems, such as modifications of the Clavien Dindo System. Analyzing reoperations at the primary site may enable a better understanding of reasons for failure, and may therefore improve the outcomes of surgery in the future.

Level of Evidence: Level III, retrospective comparative cohort study based on prospectively collected data.

Keywords: ankle arthritis, ankle fusion, ankle arthrodesis, total ankle replacement, total ankle arthroplasty, reoperations reporting, complications, coding

Introduction

The analysis of operative complications in outcomes research is critically important and may reduce future patient morbidity. It allows the surgeon to appropriately counsel the patient on the risks of a proposed procedure. Standardized classification systems are frequently used for the reporting of these adverse events.[2] Unfortunately, the development and implementation of such classifications systems is problematic, because of the difficulty of achieving consensus and widespread adoption among specialists in a particular field.[3] Without uniform criteria, it is not possible to accurately compare complication and adverse-event reports from different research groups.

The Canadian Orthopaedic Foot and Ankle Society (COFAS) Ankle Arthritis Study Group was formed in 2002 in order to develop a multicenter database of clinical outcomes of ankle arthrodesis and total ankle replacement. As the project progressed, however, it became clear that the terminology used in the literature to describe adverse events associated with these procedures was highly variable and inconsistent.[7]

Some effort has been made to address this problem. For example, an evidence-based review of complications by Glazebrook et al[3] has proposed that complications be classified according to their severity (eg, deep infection, aseptic loosening, and implant failure should be considered to be "high-grade" complications, whereas wound-healing problems should be considered "low grade").

We propose that a more useful method for evaluating the efficacy and safety of a procedure would analyze complications based on the frequency of reoperation (ie, additional surgery at or surrounding the original operative site) associated with the primary procedure. The need for reoperation adversely affects outcome in ankle-joint replacement and arthrodesis.[5] Excess resource utilization after a procedure can provide a measure of the impact of unanticipated intra- or postoperative events. This is more useful than current complication reporting, which suffers from a threshold effect, is diagnosis-based, and is therefore subject to interpretation.

In this article, we propose a simple classification framework for coding and reporting complications and adverse events in patients requiring reoperation following the operative treatment of ankle arthritis. The goal was to provide a more reproducible method for the comparison of outcomes (eg, for ankle replacement vs ankle arthrodesis, etc) Understanding how these outcomes impact resource utilization may ultimately reduce the cost of care.

Methods

The COFAS Ankle-Arthritis Study Group is composed of 6 surgeons at 4 clinical sites. Design of the outcome database began in 2002, and over the following 10 years, the group met 4 times yearly to develop the coding system. The definition of an individual "reoperation event" was outlined, and a hierarchy of reoperation severity was established. A consensus definition was then developed for each code, in ascending order from 1 to 11. Each type of reoperation event was then assigned a specific code, based on the definitions listed below and shown in Table 1. All reoperations in the database were then coded using this framework. Patients were followed from 2002 to minimum 2-year follow-up by March 2012, for follow-up in March 2014.

A total of 213 ankle arthrodeses and 474 total ankle replacements in 652 patients were prospectively followed for a minimum of 2 years. Baseline characteristics of the full cohort and the 2 patient subgroups are summarized in Table 2. Enrollment and follow-up numbers are shown in Figure 1. Mean follow-up duration was 56.9 ± 22.7 months for the ankle arthrodesis procedures and 63.3 ± 26.6 months for the ankle replacement procedures.

A "reoperation code" was defined as 1 event per ankle replacement or arthrodesis. This limit was selected because more than 1 reoperation for a single condition (such as infection) may be difficult to separate and define. If a period of stable function existed for at least 2 years after reoperation, subsequent reoperation was treated as a separate event and assigned a second reoperation code. For a series of reoperations (such as for 2-stage revision for infection) a single code was used. The reoperation codes were stratified by severity, and when more than one code existed, the more severe code was used. Because there was good inter- and intraobserver reliability (see Results), and some hospitals ethics review boards did not allow distribution of operation reports to other surgeons, the code used was the one assigned by the treating surgeon.

Informed consent was obtained from all patients both for surgery and for study participation prior to the procedure. Ethical approval was obtained from the institutional review board at each site.

Inclusion criteria for total ankle replacement or arthrodesis were skeletal maturity (age of 19 years or older), failure of nonoperative treatment of end-stage ankle arthritis,

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Table 1. COFAS Reoperations Coding System (CROCS).

Type	Code	Description of Reoperation	Applicable Procedure
Nil	1	No reoperation within or surrounding the ankle	Ankle replacement or arthrodesis
Reoperation surrounding primary operative site	2	Isolated hardware removal around the ankle	Ankle replacement or arthrodesis
	3	Repeat operation outside the ankle replacement or arthrodesis (eg, osteotomy, fusion, or ligament repair) but related to the replacement or arthrodesis	Ankle replacement or arthrodesis
Reoperation within primary operative site	4	Ankle gutter or heterotopic ossification debridement without exchange of metal components, with or without intact polyethylene exchange	Ankle replacement only
	5	Exchange of polyethylene liner as a result of polyethylene liner failure	Ankle replacement only
	6	Debridement of an osteolytic cyst without exchange of metal components, with or without intact polyethylene exchange	Ankle replacement only
	7	Deep infection or wound complication requiring operative debridement (without exchange of metal components in ankle replacement), with or without intact polyethylene exchange	Ankle replacement or arthrodesis
	8	Revision of arthrodesis due to malposition or nonunion (no infection)	Ankle arthrodesis only
	9	Implant failure leading to revision of metal components due to aseptic loosening, component fracture, or malposition (no infection)	Ankle replacement only
	10	Revision of metal component(s) secondary to infection	Ankle replacement only
Amputation	11	Amputation above the level of the ankle	Ankle replacement or arthrodesis

Standardized codes for reoperations due to complications or adverse events following ankle arthrodesis or replacement.

Table 2. Baseline Characteristics of All Ankles Enrolled in Present Study.

Characteristic	Ankle Arthrodesis (n = 213)	Ankle Replacement (n = 474)
Age, mean (±SD), y	55.1 (±12.0)	63.3 (±10.7)
Male sex	130 (61%)	233 (49%)
BMI, mean (±SD), kg/m^2	29.0 (±5.0)	28.0 (±4.8)
Patients with inflammatory arthritis	25 (12%)	106 (22%)
Regular smokers	23 (11%)	21 (4%)
Mean follow-up (±SD), mo	56.9 (±22.7)	63.3 (±26.6)
Patients with diabetes	29 (14%)	39 (8%)
Surgery, left side	102 (48%)	222 (47%)
Percentage of patients assigned to surgeon A/B/C/D/E/F	24/14/21/17/19/4	7/15/44/7/22/5

ability and willingness to give informed consent. Exclusion criteria for surgery were Charcot arthropathy, poorly controlled diabetes, osteonecrosis of the talus, active or prior infection, and poor vascularity. Exclusion criteria for the present study were an inability to communicate or fill out questionnaires, age under 19, prior ankle arthrodesis or replacement.

Study Size Calculation

The total number of patients reflects the total enrollment within the study sites. As this was an observational study, no power analysis was performed.

Procedure Selection

The decision regarding operative treatment selection for each patient and ankle (ie, ankle replacement or arthrodesis) was not randomized. Rather, it reflected current standards of practice and consensus between surgeon and patient.

Data Collection

Data were collected at each study site prior to surgery and yearly thereafter. Reoperations were recorded on an ongoing basis at each site. Recording was limited to local reoperations at or surrounding the surgical site. Patient demographics,

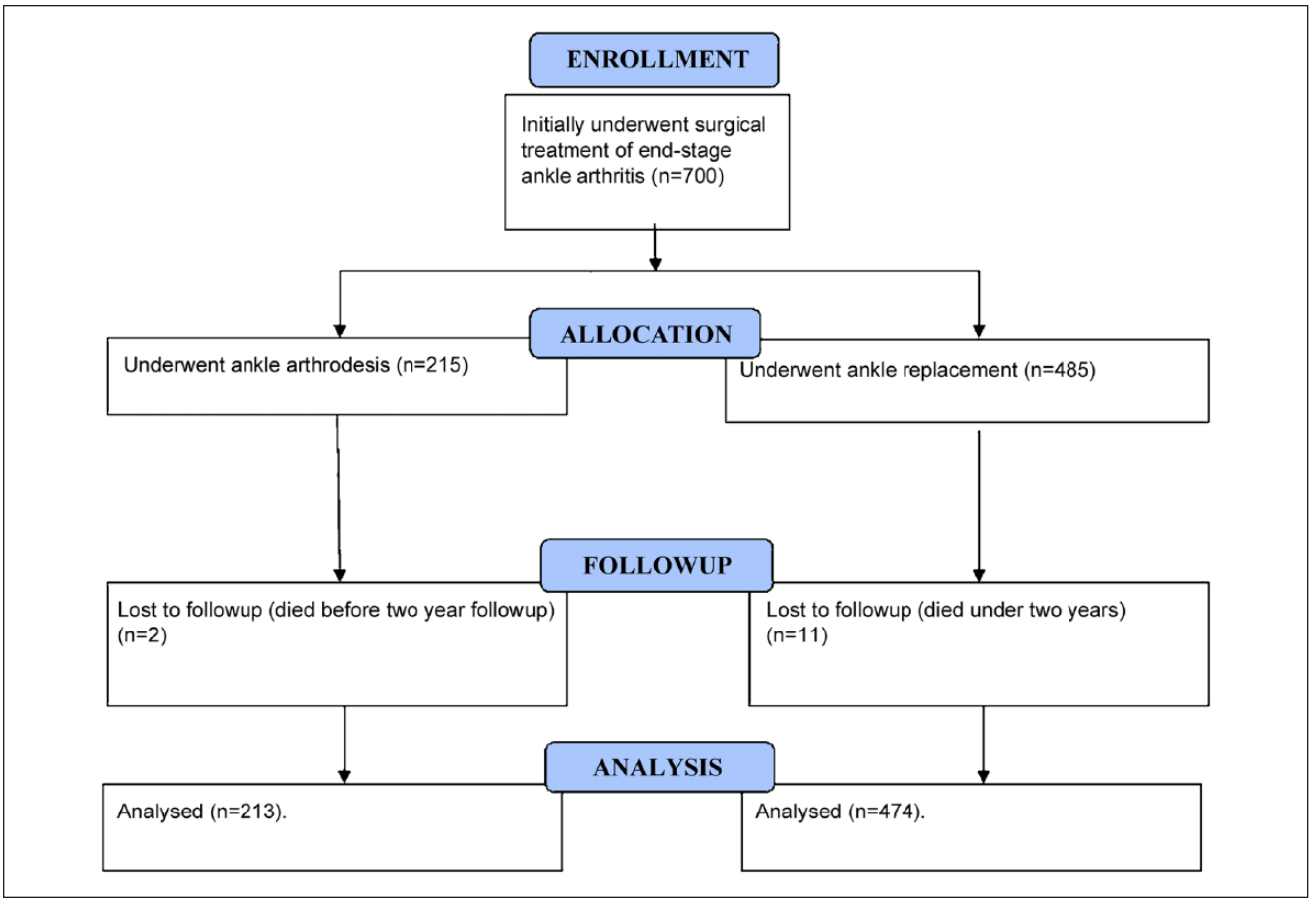

Figure 1. Flow diagram of patient enrollment, follow-up, and analysis.

comorbidities, and diagnoses were recorded preoperatively. Operative details and reoperation data were also collected.

Surgical Technique

Ankle arthrodeses were performed with cartilage debridement using either an arthroscopic approach and stable screw fixation or an open technique. Open arthrodeses were performed either in isolation or combined ankle and subtalar fusion using screws, plates, or a retrograde rod. Bone grafting with autograft or bone-graft substitute was performed according to surgeon preference.

Patients undergoing ankle replacement received one of 4 prostheses: the Agility semi-constrained prosthesis (DePuy, Warsaw, IN); the Scandinavian Total Ankle Replacement (STAR) mobile bearing prosthesis (Waldemar Link, Hamburg, Germany; now distributed by SBI, Morrisville, PA); the Mobility mobile bearing prosthesis (DePuy, Leeds, United Kingdom); or the Hintegra mobile bearing prosthesis (Integra Life Sciences, Plainsboro, NJ).

Standard operative procedure was used. Two of the ankle joint replacements (The Agility and STAR) were no longer used after 2007.

Outcome Measures

The primary outcome measure was the COFAS Reoperations Coding System (CROCS) presented in the current study (Table 1).

Inter- and Intraobserver Reliability

Inter- and intraobserver reliability of the coding system were determined as follows: Six fellowship-trained surgeons experienced in foot and ankle surgery reviewed 61 reoperations from one surgeon's practice and assigned a code to each reoperation. This process was repeated after a 2-week interval. Reoperations were blinded via random numbering on each occasion. The interclass correlation coefficient (ICC) was calculated, as well as the number of times complete agreement occurred between pairs of observers and across all 6 observers (interobserver reliability), and the number of times each observer's second round of coding agreed with their first round (intraobserver reliability). The agreement between pairs of readings (915 for interobserver for the first and second read: 61 readings with 15 comparisons, observer 1 with observer 2, observer 1

Table 3. Number and Percentage of Ankles That Required Reoperation Following Ankle Replacement or Ankle Arthrodesis, Grouped by Code Using the COFAS Reoperations Coding System (CROCS) Presented in Table 1.

Code	Reoperation Category	Ankle Arthrodesis (n = 213)	Total Ankle Replacement (n = 474)
1	No reoperation	183 (85.9%)	331 (69.8%)
2	Isolated Hardware removal	19 (8.9%)	6 (1.3%)
3	Reoperation outside initial operative site	2 (0.9%)[a]	22 (4.6%)
4	Gutter or heterotopic ossification debridement	N/A	27 (5.7%)
5	Polyethylene liner exchange	N/A	12 (2.5%)
6	Debridement of osteolytic cyst	N/A	13 (2.7%)
7	Deep infection requiring debridement	2 (0.9%)	11 (2.3%)
8	Revision of arthrodesis	8 (3.8%)	N/A
9	Revision of metal components because of implant failure	N/A	51 (10.8%)[b]
10	Infection requiring revision of metal components	N/A	10 (2.1%)[c]
11	Amputation	3 (1.4%)	4 (0.8%)

[a]Of the 2 Code 3 events for ankle arthrodesis, one was a subtalar fusion and the other a calcaneal osteotomy plus subtalar fusion.
[b]Reoperation due to implant failure occurred 51 times in 49 ankles.
[c]Reoperation due to infection occurred 10 times in 7 ankles.

with observer 3, etc) was determined by seeing how often each observer agreed. This was repeated for the 366 ratings for intraobserver readings (61 times 6). For definition of terminology see the Appendix.

Statistical Analysis

Inter- and intraobserver reliability were summarized using ICCs and proportions of exact agreement between pairs of observers and across all observers.

Sources of Funding

Direct or indirect research funding support for this study was received from Integra LifeSciences Corporation, Wright Medical Technology Inc, Synthes, Biomimetic Therapeutics Inc, ConMed Linvatec, BioSET Inc, and Smith & Nephew. An unrestricted research grant was received from DePuy to support data collection on the Mobility prosthesis for each patient. Some patients receiving a Mobility total ankle replacement at one site were also part of an independent radiostereometric analysis study that was supported by an unrestricted research grant from DePuy.

Results

Table 3 shows the results of the present study, for reoperations following ankle arthrodesis or replacement in a total of 687 ankles. The number and percentage of ankles that required reoperation were grouped by category using the COFAS Reoperations Coding System (CROCS) shown in Table 1. Among all procedures, 74.8% (514/687) were classified as Code 1 (ie, required no reoperation). Fewer reoperations were required following arthrodesis, with 85.9% (183/213) of surgeries classified as Code 1 versus 69.8% for ankle replacement (331/474). The rate for reoperations surrounding the ankle joint (ie, Codes 2 and 3) was 9.9% (21/213) for ankle arthrodesis versus 5.9% for ankle replacement (28/474). Rates for reoperation within the ankle joint (ie, Codes 4 to 10) were 4.7% (10/213) for ankle arthrodesis versus 26.1% (124/474) for ankle replacement. The rate of amputation (ie, Code 11) was 1.4% for ankle arthrodesis (3/213) and 0.8% for ankle replacement (4/474). 3.6% (25/687) of all reoperations were classified as Code 2 (isolated hardware removal), with 8.9% (19/213) for ankle arthrodesis and 1.3% (6/474) for ankle replacement. In addition, 0.9% (2/213) of reoperations following arthrodesis and 4.6% (22/474) following ankle replacement were classified as Code 3 (reoperation outside the operative site but related to arthrodesis, including surrounding joint fusions).

For codes applicable only to ankle replacement (ie, Codes 4, 5, 6, 9, and 10), 5.7% (27/474) of reoperations were classified as Code 4 (debridement for heterotopic ossification or gutter impingement); 2.5% (12/474 in 10 ankles) were classified as Code 5 (isolated polyethylene liner exchange due to failure); 2.7% (13/474) were classified as Code 6 (debridement of osteolytic cyst without exchange of metal components); 10.8% (51/474 in 49 ankles) were classified as Code 9 (revision of metal components for malposition or loosening due to implant failure); and 2.1% (10/474 in 7 ankles) were classified as Code 10 (infection requiring revision of metal components).

Overall, 1.9% (13/687) of reoperations for all ankles were classified as Code 7 (deep infection requiring debridement), with 0.9% (2/213) for arthrodesis versus 2.3% (11/474) for ankle replacement (P = NS). In addition, 3.8% (8/213) of reoperations following arthrodesis were classified as Code 8 (revision of arthrodesis due to malposition or nonunion).

Table 4. Interclass Correlation Coefficients for Inter- and Intraobserver Reliability: First Read.

	A1	B1	C1	D1	E1	F1
A1						
B1	0.84					
C1	0.87	0.96				
D1	0.87	0.90	0.95			
E1	0.87	0.95	0.95	0.88		
F1	0.81	0.88	0.92	0.92	0.80	

Average: 0.89.

Table 5. Interclass Correlation Coefficients for Inter- and Intraobserver Reliability: Second Read.

	A2	B2	C2	D2	E2	F2
A2						
B2	0.92					
C2	0.96	0.93				
D2	0.95	0.94	0.97			
E2	0.95	0.95	0.97	1.00		
F2	0.93	0.92	0.92	0.90	0.91	

Average: 0.94.

Inter- and Intraobserver Reliability for the Coding Scheme

The interobserver reliability on the first read had a mean ICC of 0.89. The range for the 15 comparisons was 0.81 to 0.96 (Table 4). Among all 1830 paired codings between 2 observers, 87.7% (1605/1830) were in agreement. Across the 61 cases, 73.8% (45/61) were given the same code by all 6 observers. The interobserver reliability test on the second read had a mean ICC of 0.94, with a range of 0.90 to 1.0 (Table 5). Overall, 72.1% (44/61) of observations were the same across all 6 observers. Of all pairs, 87.9% (804/915) were in agreement for the first reading, with 12.1% (111/915) disagreement. For the second reading, there was agreement in 87.5% (801/915) of all pairs and disagreement in 12.5% (114/915).

The intraobserver reliability averaged an ICC value of 0.92, with a range of 0.86 to 0.98. The observers agreed with their own previous observations 324 times out of 366 paired readings (88.5% agreement of pairs). The intraobserver reliability correlation matrix, first read to second read, is shown in Table 6.

Discussion

This paper presents a new coding system for outcome reporting following ankle arthrodesis or replacement. We have evaluated the inter- and intraobserver reliability of the system, and found it to be reliable. Outcomes for ankle arthrodesis versus total ankle replacement were also compared. A crucial benefit of the systematic reporting of complications and adverse events is that it may lead to more standardized reporting, which may in turn reveal design flaws in implants or suggest improvements in procedure. The coding system proposed here is based on the type of reoperation needed in order to address a particular complication or adverse outcome, as opposed to the outcome itself. This approach addresses both the difficulty of achieving consensus regarding complications terminology, and also the practical impact of excess resource utilization. For example, a wound complication may be reported as "wound infection," "wound necrosis," or "wound breakdown." The practical significance, however, is that the wound may result in an extra surgery, extra clinic visits, or extra days in hospital—in other words, additional costs to both the patient and the health care system.

This coding system was designed to capture all major adverse events, and to enable consistent, reproducible reporting of reoperations. Such consistency will allow more accurate comparisons of results between various research groups and from one report to another. This, in turn, will enhance survivorship analyses in prospective studies. The system is easy to use and can be employed by both surgeons and study coordinators.

In the general surgery literature, reoperations due to operative procedures are often classified and stratified with the Clavien-Dindo classification system.[2] Modifications of this system have been used for many orthopedic surgeries.[4,6,9] However, although this scale is applicable to general operative reoperations (eg, pancreatitis or liver insufficiency), it is not particularly useful for the specific reoperations encountered in orthopedic subspecialties (eg, nonunion, wound breakdown, polyethylene failure, or aseptic loosening).

The literature on ankle-joint replacement has been especially inconsistent regarding the terms used to report reoperations. For example, in a meta-analysis of the STAR system, Zhao et al[10] reviewed a total of 2008 replacements in 16 studies. Survivorship at 5 years varied from 100% to 70%, and aseptic loosening was the main cause of failure. In only 7 of the 16 studies were the timing and reason for each failure reported.

In a recent study, Brunner et al[1] calculated that the 10-year survivorship among 77 STAR ankles was 70%; however, a separate survivorship curve for aseptic loosening was not included. Polyethylene failure was included in the overall survivorship analysis. Survivorship was down to 46% at 14 years. Aseptic loosening occurred in 10 of the 29 failed cases (34%), and subsidence of the talar component in a further 10 cases.

In a systematic review of the Agility prosthesis, Roukis et al[8] analyzed outcomes from 14 papers, for a total of 2312 ankle replacements, of which 224 underwent revision. Revision to another replacement was performed in

Table 6. Intraobserver Reliability Correlation Matrix, First Read to Second Read.

A1 to A2	B1 to B2	C1 to C2	D1 to D2	E1 to E2	F1 to F2	Mean
0.86	0.89	0.98	0.97	0.89	0.91	0.92

182 (81%) of those revisions. For 87 cases (47%), no cause for reoperation was identified, whereas the terms *malalignment, subsidence, migration, aseptic loosening, osteolysis*, or *instability* were used to describe the cause for another 80 revisions (44%). *Undersizing* was listed 15 times as the cause of revision surgery. For revision of a failed total ankle arthroplasty to arthrodesis, 25 of 34 cases also had no specific cause of revision listed.

More complete and consistent reporting will also benefit patients, by providing their surgeons with more accurate data regarding the outcome of a particular procedure. Complication rates and specific modes of failure can directly affect the process of operative decision making. Clear, accurate, evidence-based information regarding adverse events is therefore essential if surgeons are to make wise decisions and advise their patients appropriately.

This simplified coding will potentially also provide more useful data to guide improvements in prosthetic design and operative procedures. Reliable complication reporting allows surgeons and prosthesis engineers to recognize specific factors that, if changed, could reduce risks and improve outcomes. Although various aspects of prosthesis design (eg, ingrowth surfaces, fixation to bone) may not affect infection rates, they may well affect aseptic loosening rates.

Rising health care costs are another consideration. In the future, complication reporting will need to focus not only on design parameters but also on cost and impact on the patient. For prospective studies, a record of unplanned clinic visits and unplanned hospital days may provide a more reliable method of analyzing the impact of reoperations on costs.

Potential limitations of the present study include the heterogeneity of the patient population, the possible mutual independence of some complications and some reoperations, and the fact that the reported ICCs provide only a broad summary of observer reliability, as the numeric codes in the proposed coding system do not reflect complication severity on an interval scale. (An interval scale has yet to be developed at this time.) Additionally, this longitudinal cohort comparison was not a randomized controlled trial and did not compare identical patients and procedures; rather, it reflected patterns of practice. Caution must be exercised in comparing reoperation rates between procedures.

Conclusions

The simplified coding framework detailed in this report has worked well for the COFAS Ankle-Arthritis Study Group, and we feel that it will enhance reporting of outcomes for ankle arthrodesis or replacement. We recommend that the main reoperation-coding categories be used as a standard, minimum requirement for reporting and classifying complications in future outcome studies. Subcodes might also be added in order to enhance the level of detail in a report, and therefore its usefulness to the clinical and research communities. Ultimately, the goal is to reduce reoperations on or around the operative site and to reduce resource utilization. In conclusion, we believe that this structure of reporting may provide a more appropriate method of defining the potential downside of surgery to aid in the improvement of operative outcomes and patient care.

Appendix: Definition of Terms

Revision of metal components: Indicates that one or both components of a total ankle replacement were revised, during 1 or more operations.

Reoperation: May include 1 or more revision operations. For survivorship analysis, the first of these events to be coded from 1 to 6 may be considered the end point. If more than 1 event occurred, only a single code is used (ie, the event with the highest number score is used to define the event). The survivorship of components and polyethylene may be tracked and considered separately. More than 1 code can be used if a period of stable function (greater than 2 years) exists between events. If more than 1 event is recorded per ankle, this needs to be outlined in the methods and results as the events are no longer independent.

Polyethylene exchange: Indicates that only the polyethylene component was exchanged, for reasons associated with polyethylene wear or failure without hardware exchange. Polyethylene exchange for infection is coded under deep infection.

Deep infection: A revision surgery for debridement without removal or exchange of metal components. Polyethylene may or may not be exchanged.

Revision of nonunion and malunion: Applies to ankle arthrodesis in which the fusion site has failed to unite or has healed in a poor position, requiring revision arthrodesis at the same site.

Revision of metal components without infection: Removal of one or both metal components for aseptic loosening, fracture, or malposition. The reconstruction (arthrodesis, excision arthroplasty or revision replacement) is not considered in the minimal reporting unless an amputation is performed.

Revision for septic loosening: Revision of an infected ankle with removal of the metal components in order to resolve the infection, with or without a 2-stage exchange, regardless of the final reconstruction (unless an amputation is performed).
Amputation: Indicates an amputation above the level of the ankle for reasons related to the reconstruction.
Systemic event: A complication outside the local area of the ankle and foot. Systemic reoperations may be considered common to all types of surgery. If a systemic complication occurs, it should be classified separately as outlined in Table 1. In past studies, these have not been a routine part of complication reporting for end-stage ankle arthritis, but on occasion thromboembolic reoperations have been reported.

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Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Alastair S. E. Younger, MBChB, ChM, FRCSC, has a patented fastening device for total ankle arthroplasty licensed to Dr. Younger.

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Assistant Editor's Note

The current multicenter study proposes to standardize a simpler, fresh approach to gauge the relative efficacy and safety of total ankle replacements and ankle arthrodesis through coding of related reoperations to reflect complications and adverse events. Fundamentally, it is easier to code reoperations rather than other parameters including indications, comorbidities, and complications. The study follows a decade of multicenter consensus in the development of a coding system of reoperations and database following total ankle replacement and ankle arthrodesis, which potentially creates an avenue of ready recording and easy access to vital data of reoperations and adds certain objective comparability and transparency. The authors also documented good interobserver and intraobserver reliability for the coding.

Secondly, the retrospective comparative study of ankle arthroplasty and arthrodesis groups for end-stage ankle arthritis for Level III evidence is based on prospectively acquired data of the database within limitations. In particular, this longitudinal cohort admittedly did not compare identical patients and procedures as the authors did not exclude associated subtalar fusions and tibiotalocalcaneal fusions, which are potential confounders for the comparative study. Although the discretionary patterns of surgical practice in the context of associated subtalar arthritis are a measure of acceptable surgical judgment and reflect realistic current clinical practice, the resultant heterogeneity in the 2 study groups implies that conclusions of the present study are subject to limitations and are arguably defendable within limitations. I am, however, enthusiastic that future expansion of the database in the next decade is likely to contribute more focused studies, stratification, and additional outcomes.

An ideal database should be procedure-specific, implant-specific, technique-specific, interval-specific, indication-specific, comorbidity-specific, complication-specific, outcome-specific, and finally even possibly patient-specific. Evolution of database may never be viewed as comprehensive and final (and never free from limitations) despite interim additions of significant contributions.

The authors' contribution of coding of reoperations following ankle arthroplasty and arthrodesis facilitates objective data despite various limitations and constitutes an important interim step in database evolution for ankle arthroplasty and arthrodesis.

Kodali Siva R. K. Prasad, MD
Assistant Editor

References

1. Brunner S, Barg A, Knupp M, et al. The Scandinavian total ankle replacement: long-term, eleven to fifteen-year, survivorship analysis of the prosthesis in seventy-two consecutive patients. *J Bone Joint Surg*. 2013;95(8):711-718.
2. Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: five-year experience. *Ann Surg*. 2009;250(2):187-196.
3. Glazebrook MA, Arsenault K, Dunbar M. Evidence-based classification of complications in total ankle arthroplasty. *Foot Ankle Int*. 2009;30(10):945-949.
4. Iorio R, Della Valle CJ, Healy WL, et al. Stratification of standardized TKA complications and adverse events: a brief communication. *Clin Orthop Relat Res*. 2014;472(1):194-205.
5. Krause FG, Windolf M, Bora B, et al. Impact of complications in total ankle replacement and ankle arthrodesis analyzed with a validated outcome measurement. *J Bone Joint Surg*. 2011;93(9):830-839.
6. Martus JE, Preston RK, Schoenecker JG, et al. Complications and outcomes of diaphyseal forearm fracture intramedullary nailing: a comparison of pediatric and adolescent age groups. *J Pediatr Orthop*. 2013;33(6):598-607.
7. Mercer J, Penner M, Wing K, Younger A. Inconsistency in the reporting of adverse events in total ankle arthroplasty: a systematic review of the literature. *Foot Ankle Int*. 2016;37(2):127-136.
8. Roukis TS. Incidence of revision after primary implantation of the Agility total ankle replacement system: a systematic review. *J Foot Ankle Surg*. 2012;51(2):198-204.
9. Sink EL, Leunig M, Zaltz I, et al. Reliability of a complication classification system for orthopaedic surgery. *Clin Orthop Relat Res*. 2012;470(8):2220-2226.
10. Zhao H, Yang Y, Yu G, Zhou J. A systematic review of outcome and failure rate of uncemented Scandinavian total ankle replacement. *Int Orthop*. 2011;35(12):1751-1758.