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Retrospective Review of Complications and Revision Rates Between Isolated Talonavicular vs Talonavicular and Subtalar (Double) Arthrodesis vs Triple Arthrodesis

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Abstract

Background: Hindfoot fusion procedures are common for the treatment of end-stage arthritis or deformity. Surgical treatments for these conditions include talonavicular joint (single) arthrodesis, talonavicular and subtalar (double) arthrodesis, or talonavicular, subtalar, and calcaneocuboid (triple) arthrodesis. This study evaluated the complication rate, revision surgery rate, and hardware removal rate for those treated with either single, double, or triple arthrodesis.

Methods: A retrospective review was conducted for patients who underwent single (*Current Procedural Terminology* [*CPT*] code 28740), double (*CPT* 28725 and 28740), or triple (*CPT* 28715) arthrodesis to treat hindfoot arthritis/deformity (*International Classification of Diseases, Ninth Revision* [*ICD-9*] code: 734, *International Classification of Diseases, Tenth Revision* [*ICD-10*] codes: M76821, M76822, and M76829) from 2005 to 2022 using the South Carolina Revenue and Fiscal Affairs databank. Data collected included demographics, comorbidities, procedure data, and postoperative outcomes within 1 year of principal surgery. Student *t* test, chi-squared test, and multivariable logistic regression analysis were utilized during data analysis.

Results: A total of 433 patients were identified, with 248 undergoing single arthrodesis, 67 undergoing double arthrodesis, and 118 undergoing triple arthrodesis. There was no significant difference between single, double, and triple arthrodesis in the rate of complications, hardware removals, revision surgeries, or 30-day readmission when controlling for confounding variables. However, a decrease in Charlson Comorbidity Index (CCI) was found to be predictive of an increase in the revision surgery rate (OR = 0.46, 95% CI 0.22-0.85, $P = .02$).

Conclusion: We found no difference in the rate of complications, hardware removals, or revision surgeries in those undergoing single, double, or triple arthrodesis. Surprisingly we found that a lower Charlson Comorbidity Index, indicating a healthier patient had a significant relationship with a higher rate of revision surgery. Further study including radiographic indications for surgery or the impact of overall health status on revision surgery rates may further elucidate the other components of this relationship.

Level of Evidence: Level III, cohort study.

Keywords: Single arthrodesis, double arthrodesis, triple arthrodesis, outcomes, complications

Introduction

Hindfoot arthritis is common and can result from inflammatory disorders, primary degenerative changes, trauma, gout, and neuropathic degeneration.[16,20,25] Given the hindfoot's important role in proper gait mechanics, arthritis in these areas can result in significant pain and physical limitations

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for patients.[16,20,25] Arthritis in the hindfoot can also result in abnormal foot posture and deformity of the foot, leading to greater physical limitations and causing significant morbidity for patients.[20] Additionally, patients can have a deformity of the hindfoot as a result of other degenerative conditions like adult-acquired flatfoot or cavovarus deformity. Surgical treatment options for end-stage hindfoot arthritis and deformity conditions can include a talonavicular joint (single) arthrodesis, talonavicular and subtalar (double) arthrodesis, or talonavicular, subtalar, and calcaneocuboid (triple) arthrodesis.[20,21,24,25] All these procedures have been demonstrated to be effective in treating the pain and functional limitations associated with several conditions of the foot and ankle.[5,8,10,12,23,24,26,27]

There have been previous studies comparing the complication and revision surgery rate for those treated with either single, double, or triple arthrodesis.[4,7,9,10,13,17,23] However, these previous studies focusing on comparing the complication and revision surgery rate had relatively small sample sizes, each with somewhat conflicting results.[4,9] Given the frequency of these procedures to treat numerous different pathologies, we sought to investigate the overall and individual complication rate, revision surgery rate, and hardware removal rate for those treated with either single, double, or triple arthrodesis. Additionally, we compared the rate of complications and revisions between these three procedures, to determine if one has a significantly different rate compared to the others. We hypothesize there will be a significant difference in complication or revision surgery rates between those treated with single, double, or triple arthrodesis, with those undergoing triple arthrodesis demonstrating a higher complication and revision surgery rate compared with those undergoing single or double arthrodesis because of the increased time of surgery and increased number of attempted fusion sites.

Methods

A retrospective review was conducted of patients who underwent either single, double, or triple arthrodesis between 2005 and 2022. Data were obtained from the South Carolina Revenue and Fiscal Affairs Office databank, a verified database for use in medical research.[3,6,14,19,28] This databank was composed of outpatient surgical procedures defined by reason for service, represented by an *International Classification of Diseases, Ninth* or *Tenth Revision* (*ICD-9* or *ICD-10*) code, and the types of services received, represented by a *Current Procedural Terminology* (*CPT*) code. Patients were included in the study if they were 18 years or older and had undergone either single arthrodesis (*CPT* 28740), double arthrodesis (*CPT* 28725 and 28740), or triple arthrodesis (*CPT* 28715), and if their procedure was associated with a diagnosis code for flatfoot (*ICD-9*: 734, *ICD-10*: M76821, M76822, M76829). Patients were excluded from the study if their index procedure was a revision surgery of a previous single, double, or triple arthrodesis. Data collected included demographic information, Charlson Comorbidity Index (CCI), postoperative complications within 1 year, prevalence of revisions surgery within 1 year, prevalence of hardware removal surgeries within 1 year, and prevalence of 30-day all-cause unplanned readmission. All recorded complications with their corresponding *ICD-9* or *ICD-10* codes are displayed in Appendix 1. Continuous data were expressed as a mean and SD. Categorical data were expressed as a proportion and a percentage. Student *t* tests and Fisher exact chi-squared tests were used to compare continuous and categorical variables, respectively. Univariable and multivariable logistic regression analysis was used to determine independent predictors for complication rate, revision surgery rate, and hardware removal rate when both not controlling and controlling for potential confounding variables, respectively. All unadjusted variables with a $P < .1$ were included in the multivariable logistic regression analysis. All $P < .05$ were considered statistically significant.

Results

A total of 433 patients were identified for inclusion in this study. Overall, 248 (57.7%) patients underwent single arthrodesis, 67 (15.6%) underwent double arthrodesis, and 118 (27.4%) underwent triple arthrodesis. Demographic information for each group is displayed in Table 1. Of note, all procedures were performed in an outpatient setting. In comparing demographic information of those undergoing single, double, and triple arthrodesis, there was found to be a significant difference between the 3 groups in average age (44.6 vs 57.6 vs 51.1, $P < .01$), CCI (0.61 vs 1.6 vs 1.4, $P < .01$), the proportion of females operated on (81% vs 61.2% vs 58.5%), and proportion of patients >65 years old (4% vs 35.8% vs 22%, $P < .1$).

The number of complications for single, double, and triple arthrodesis was 12 (4.8%), 2 (3%), and 5 (4.2%), respectively; the rate of hardware removals for single, double, and triple arthrodesis was 17 (6.9%), 3 (4.5%), and 8 (6.8%), respectively; the rate of revision surgeries for single, double, and triple arthrodesis was found to be 22 (8.9%), 8 (11.9%), and 15 (12.7%), respectively; and the rate of 30-day readmission was 7 (2.8%), 2 (3%), and 3 (2.5%), respectively. There were no significant differences in the rate of complications ($P = .95$), hardware removals ($P = .32$), revision surgeries ($P = .47$), or readmission ($P > .99$) between the 3 groups (Table 2). A post hoc power analysis demonstrated this study had an 88% power to detect a 20% difference in complication rate between our 3 groups.

In univariate logistic regression analysis, single, double, and triple arthrodesis procedures were not significantly associated with an increase in complication rate

Table 1. Demographic Information for Hindfoot Arthrodesis Patients.

	Single (n=248)	Double (n=67)	Triple (n=118)	*P* Value[a]
Age, mean (SD)	44.6 (12.3)	57.6 (14.0)	51.1 (15.6)	<**.01**
Length of stay, mean (SD)	1.5 (1.9)	1.2 (0.79)	1.8 (2.4)	.148
Charlson Comorbidity Index, mean (SD)	0.61 (0.9)	1.6 (1.2)	1.4 (1.6)	<**.01**
Age ≥65 y, n (%)				
No	238 (96)	43 (64.2)	96 (78)	<**.01**
Yes	10 (4)	24 (35.8)	26 (22)	
Sex, n (%)				
Male	47 (19)	26 (38.8)	49 (41.5)	<**.01**
Female	201 (81)	41 (61.2)	69 (58.5)	
Race, n (%)				
White	171 (68.9)	46 (68.7)	69 (58.5)	.29
Black	68 (27.4)	20 (29.8)	43 (36.4)	
Other	9 (3.6)	1 (1.5)	6 (5.1)	

[a]Boldface indicates statistical significance ($P < .05$).

Table 2. Outcome Metrics for Hindfoot Arthrodesis Patients.

	Single, n (%) (n=248)	Double, n (%) (n=67)	Triple, n (%) (n=118)	*P* Value
Complication	12 (4.8)	2 (3)	5 (4.2)	.95
Hardware removal	17 (6.9)	3 (4.5)	8 (6.8)	.32
Revision surgery	22 (8.9)	8 (11.9)	15 (12.7)	.47
Readmission	7 (2.8)	2 (3)	3 (2.5)	>.99

Table 3. Unadjusted Univariate Odds Ratio of Complications, Hardware Removal, Revision, and Readmission for Hindfoot Arthrodesis Patients.

	Odds Ratio	95% CI	*P* Value
Complication			
Single	1.3	0.51-3.5	.6
Double	0.63	0.1-2.3	.55
Triple	0.95	0.3-2.5	.93
Hardware removal			
Single	1.7	0.83-3.7	.16
Double	0.49	0.11-1.4	.25
Triple	0.78	0.32-1.7	.54
Revision			
Single	0.9	0.4-1.9	.78
Double	1.3	0.5-3.2	.54
Triple	0.92	0.38-2.0	.85
Readmission			
Single	1.8	0.7-5.1	.25
Double	0.96	0.22-2.9	.95
Triple	0.46	0.11-1.4	.22

($P = .6, .55, .93$), hardware removal rate ($P = .16, .25, .54$), revision surgery rate ($P = .78, .54, .85$), or 30-day readmission ($P = .25, .95, .22$) (Table 3).

Table 4. Multivariable Logistic Regression Analysis for Revision Surgery in Single, Double, and Triple Arthrodesis.

	Odds Ratio	95% CI	*P* Value[a]
Single arthrodesis	0.72	0.32-1.7	.44
Double arthrodesis	1.8	0.59-4.7	.27
Triple arthrodesis	0.99	0.39-2.3	.97
Male sex	1.5	0.63-3.4	.34
Age ≥65 y	1.1	0.13-7.0	.91
Charlson Comorbidity Index	0.46	0.22-0.85	**.02**

[a]Boldface indicates statistical significance ($P < .05$).

In a multivariable logistic regression analysis, a decrease in CCI was found to be an independent predictive factor for an increase in revision surgery rate (OR = 0.46, 95% CI 0.22-0.85, $P = .02$) when controlling for confounding variables. However, single, double, and triple arthrodesis were not found to be independent predictors of an increase in complication rate ($P = .48, .51, .84$), hardware removal rate ($P = .52, .45, .94$), revision surgery rate ($P = .44, .27, .97$), or 30-day readmission rate ($P = .36, .89, .39$) when controlling for confounding variables (Table 4) (Appendix Table 1-3).

Discussion

Hindfoot arthritis and deformity are a common cause of pain, physical limitation, and foot deformity in adults.[16,20,25] Surgical treatment is recommended in patients with significant morbidity associated with these disorders.[16,20,25] Treatment can include a single, double, or triple arthrodesis, depending on the location of the affected joints and other patient-specific factors.[20,25] Although all have been demonstrated to be effective in treating various foot and ankle conditions, there is limited and conflicting evidence regarding the rate of complications and revision surgery rate for these three procedures.[4,9] The results of this study demonstrated no significant difference in the rate of complications, hardware removals, revision surgeries, or 30-day readmissions between single, double, and triple arthrodesis procedures, even when controlling for potential confounding variables. The only significant correlation was between the CCI and the revision surgery rate.

An interesting finding concerned the predictive ability of CCI regarding revision surgery rate. Our study found a decrease in CCI, representing an overall healthier patient, was an independent predictive factor for a higher revision surgery rate in those who had undergone either single, double, or triple arthrodesis procedures. Although not previously identified regarding hindfoot arthrodesis procedures, the current literature is conflicting regarding the effect of an increase in comorbid conditions on rates of revisions in foot and ankle surgery.[1,11,15,18,22] A potential cause of this finding is related to a central component of the CCI equation: age. A study by Mulligan et al[18] found that older patients were less likely to undergo reoperation following elective ankle and hindfoot reconstruction, with the reasoning being that the risks of reoperation increase with age, and, as such, fewer older patients received reoperation surgeries. This reasoning could potentially explain our findings, although it is worth noting that age $\geq$65 years was a component of our multivariable analysis and was not found to be significantly associated with an increase in revision surgery rate. Another hypothesis is that younger patients have higher demands and may not accept an inferior result and are more willing to undergo revision surgery. Further study into this result is necessary to fully understand the relationship between CCI and the rate of revision surgery following single, double, or triple hindfoot arthrodesis.

Improvement in outcomes following a surgical procedure can be delayed or inhibited by postoperative complications. Pell et al[21] found, in those undergoing triple arthrodesis, 11 of 132 had a postoperative complication, whereas Anand et al[2] demonstrated 4 complications in 18 patients following double arthrodesis. However, these studies did not focus on comparing the complication rate between single, double, and triple arthrodesis for hindfoot arthritis and deformity. The results of the current study demonstrate similar rates of complications among those treated with single, double, or triple arthrodesis, even when controlling for multiple potential confounding variables through a multivariate analysis. The larger cohorts in this study allowed for an 88% power to detect a 20% difference, adding statistical rigor to this study. This information may be valuable for surgeons when counseling a patient regarding the risk of complications for either single, double, or triple arthrodesis procedures.

Currently, there is limited evidence regarding whether there is a difference in the revision surgery rate or hardware removal rate between those treated with single, double, or triple arthrodesis. De Groot et al[7] found a 17% revision rate in those undergoing triple arthrodesis and Mann et al[17] found a 12.5% revision rate for double arthrodesis for adult-acquired flatfoot, and no current studies have reported an isolated talonavicular arthrodesis revision surgery rate. However, these previous studies did not compare the rate of revision surgery or hardware removal between those treated with single, double, or triple arthrodesis. In the current study, revision surgery rates for single, double, and triple arthrodesis were 12.7%, 11.9%, and 8.9%, which are comparable to the results of previously cited literature. Additionally, there was found to be no significant difference in the rate of revision surgery or hardware removal for those treated with single, double, or triple arthrodesis when controlling for confounding variables. The results of this study concur with the previous literature on the topic and suggest there is a relatively low rate of revision surgery and hardware removal associated with single, double, and triple arthrodesis.

There are several limitations to our study. The nature of a retrospective review prevents us from controlling for variables at the time of surgery, which may limit the validity of our results. Additionally, the data for this study are taken from a database maintained by the South Carolina Revenue and Fiscal Affairs, the state office charged with providing publicly sourced data across all state agencies and state-supported entities. It is worth noting that migration out of the database may occur if patients are treated postoperatively outside of the state of South Carolina. *ICD-9*, *ICD-10*, and *CPT* codes were used to define our study groups and outcomes. As such, improper coding may result in either over- or underestimation of certain disease states, which in turn can limit our ability to generalize these results to a larger population. Additionally, although we controlled for observable variables, including age, sex, race, and comorbidities, there are unobservable factors, such as surgeon experience and preference, or unrecorded variables, such as clinician cluster, which could not be controlled for and may introduce bias into our results. Finally, the database we obtained our data from does not contain radiographic indications for surgery. Despite these limitations, our study is one of the first to conduct a database study to generate the large cohort necessary to directly

compare the rates of complications and postoperative outcomes between those who underwent single, double, or triple arthrodesis.

Conclusion

There was no statistically significant difference in the rate of complications, hardware removals, revision surgeries, or 30-day readmissions in those undergoing single, double, or triple arthrodesis for the treatment of hindfoot deformity/arthritis. However, a lower Charlson Comorbidity Index, indicating a healthier patient, did have a significant relationship with a higher rate of revision surgery. Further study including radiographic indications for surgery or the impact of overall health status on revision surgery rates may further elucidate the other components of this relationship.

Ethical Approval

Ethical approval for this study was obtained from the Prisma Health Institutional Review Board [2042199-1].

Declaration of Conflicting Interests

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Appendix Table 1. Multivariable Logistic Regression Analysis for Complications in Single, Double, and Triple Arthrodesis.

	Odds Ratio	95% CI	*P* Value
Single arthrodesis	1.5	0.51-4.7	.48
Double arthrodesis	0.6	0.09-2.3	.51
Triple arthrodesis	0.89	0.27-2.6	.84
Male sex	1.1	0.34-3.3	.83
Age ≥65 y	1.1	0.19-5.9	.84
Charlson Comorbidity Index	1.0	0.54-1.6	.94

Appendix Table 2. Multivariable Logistic Regression Analysis for Hardware Removal in Single, Double, and Triple Arthrodesis.

	Odds Ratio	95% CI	*P* Value
Single arthrodesis	1.3	0.58-3.1	.52
Double arthrodesis	0.61	0.14-1.9	.45
Triple arthrodesis	0.97	0.38-2.2	.94
Male sex	0.69	0.26-1.7	.43
Age ≥65 y	1.5	0.26-7.8	.62
Charlson Comorbidity Index	0.62	0.33-1.03	.10

Appendix Table 3. Multivariable Logistic Regression Analysis for Readmission in Single, Double, and Triple Arthrodesis.

	Odds Ratio	95% CI	*P* Value
Single arthrodesis	0.91	0.25-4.4	.36
Double arthrodesis	1.1	0.23-3.9	.89
Triple arthrodesis	0.54	0.12-1.8	.39
Male sex	1.1	0.39-3.6	.87
Age ≥65 y	0.48	0.02-4.2	.55
Charlson Comorbidity Index	0.85	0.44-1.4	.57

Appendix 1

Complications and the Corresponding ICD-9 and ICD-10 Codes

1. Superficial surgical site infection
   - *ICD-9*:
     - 998
   - *ICD 10*:
     - T81.40XA - Infection following a procedure, unspecified, initial encounter
     - T81.49XA - Infection following a procedure, other surgical site, initial encounter
     - T81.41XA - Infection following a procedure, superficial incisional surgical site, initial encounter
     - T81.4XXA - Infection following a procedure, initial encounter—as a primary diagnosis code

2. Deep incisional surgical site infection
   - *ICD-10*:
     - T81.42XA - Infection following a procedure, deep incisional surgical site, initial encounter
     - T81.43XA - Infection following a procedure, organ and space surgical site, initial encounter

3. Wound dehiscence
   - *ICD-9*:
     - 998.30
   - *ICD-10*:
     - T81.30XA - Disruption of wound, unspecified, initial encounter
     - T81.30XD - Disruption of wound, unspecified, subsequent encounter

        - T81.31XA - Disruption of external operation (surgical) wound, not elsewhere classified, initial encounter
        - T81.31XD - Disruption of external operation (surgical) wound, not elsewhere classified, subsequent encounter
        - T81.32XA - Disruption of internal operation (surgical) wound, not elsewhere classified, initial encounter
        - T81.32XD - Disruption of internal operation (surgical) wound, not elsewhere classified, subsequent encounter
        - T81.33XA - Disruption of traumatic injury wound repair, initial encounter
        - T81.30XS - Disruption of wound, unspecified, sequela
        - S81.801A - Unspecified open wound, right lower leg, initial encounter
        - S81.801D - Unspecified open wound, right lower leg, subsequent encounter
        - S81.802A - Unspecified open wound, left lower leg, initial encounter

4. Pneumonia
    - *ICD-9*:
        - 486
    - *ICD-10*:
        - J18.1 - Lobar pneumonia, unspecified organism
        - J18.9 - Pneumonia, unspecified organism
        - J18.0 - Bronchopneumonia, unspecified organism
        - J13 - Pneumonia due to *Streptococcus pneumoniae*
        - J15.0 - Pneumonia due to *Klebsiella pneumoniae*
        - J15.1 - Pneumonia due to Pseudomonas
        - J15.211 - Pneumonia due to methicillin susceptible *Staphylococcus aureus*
        - J15.212 - Pneumonia due to methicillin resistant *Staphylococcus aureus*
        - J15.4 - Pneumonia due to other streptococci
        - J15.5 - Pneumonia due to *Escherichia coli*
        - J15.6 - Pneumonia due to other gram-negative bacteria
        - J15.7 - Pneumonia due to *Mycoplasma pneumoniae*
        - J15.8 - Pneumonia due to other specified bacteria
        - J15.9 - Unspecified bacterial pneumonia

5. Occurrences of pulmonary embolism
    - *ICD-9*:
        - 415
    - *ICD-10*:
        - I26.99 - Other pulmonary embolism without acute cor pulmonale
        - I26.92 - Saddle embolus of pulmonary artery without acute cor pulmonale
        - I26.90 - Septic pulmonary embolism without acute cor pulmonale
        - I26.93 - Single subsegmental pulmonary embolism without acute cor pulmonale
        - I26.94 - Multiple subsegmental pulmonary emboli without acute cor pulmonale
        - I26.02 - Saddle embolus of pulmonary artery with acute cor pulmonale
        - I26.09 - Other pulmonary embolism with acute cor pulmonale

6. Urinary tract infection
    - *ICD-9*:
        - 599
    - *ICD-10*:
        - N39.0 - Urinary tract infection, site not specified

7. Occurrences of cardiac arrest requiring CPR
    - *ICD-9*:
        - 427
    - *ICD-10*:
        - I97.711 - Intraoperative cardiac arrest during other surgery
        - I97.121 - Postprocedural cardiac arrest following other surgery
        - I97.191 - Other postprocedural cardiac functional disturbances following other surgery
        - T81.11XA - Postprocedural cardiogenic shock, initial encounter
        - I46.2 - Cardiac arrest due to underlying cardiac condition
        - I46.9 - Cardiac arrest, cause unspecified
        - I46.8 - Cardiac arrest due to other underlying condition

8. Myocardial infarction
    - *ICD-9*:
        - 410
    - *ICD-10*:
        - I21.02 - ST elevation (STEMI) myocardial infarction involving left anterior descending coronary artery
        - I21.09 - ST elevation (STEMI) myocardial infarction involving other coronary artery of anterior wall
        - I21.11 - ST elevation (STEMI) myocardial infarction involving right coronary artery

- I21.19 - ST elevation (STEMI) myocardial infarction involving other coronary artery of inferior wall
- I21.21 - ST elevation (STEMI) myocardial infarction involving left circumflex coronary artery
- I21.29 - ST elevation (STEMI) myocardial infarction involving other sites
- I21.3 - ST elevation (STEMI) myocardial infarction of unspecified site
- I21.4 - Non-ST elevation (NSTEMI) myocardial infarction
- I21.9 - Acute myocardial infarction, unspecified
- I21.A1 - Myocardial infarction type 2
- I24.9 - Acute ischemic heart disease, unspecified

9. Occurrences of sepsis
   - *ICD-9*:
     - 995
   - *ICD-10*:
     - A41.01 - Sepsis due to methicillin susceptible *Staphylococcus aureus*
     - A41.02 - Sepsis due to methicillin resistant *Staphylococcus aureus*
     - A41.2 - Sepsis due to unspecified staphylococcus
     - A41.3 - Sepsis due to *Haemophilus influenzae*
     - A41.4 - Sepsis due to anaerobes
     - A41.50 - Gram-negative sepsis, unspecified
     - A41.51 - Sepsis due to *Escherichia coli* [*E. coli*]
     - A41.52 - Sepsis due to Pseudomonas
     - A41.59 - Other gram-negative sepsis
     - A41.81 - Sepsis due to Enterococcus
     - A41.89 - Other specified sepsis
     - A41.9 - Sepsis, unspecified organism
     - T80.211A - Bloodstream infection due to central venous catheter, initial encounter
     - A40 - Streptococcal sepsis
     - R78.81 - Bacteremia
     - R65.20 - Severe sepsis without septic shock

10. Bleeding requiring transfusion
    - *ICD-9*:
      - 99
    - *ICD-10*:
      - D62 - Acute posthemorrhagic anemia
      - M96.830 - Postprocedural hemorrhage of a musculoskeletal structure following a musculoskeletal system procedure
      - M96.831 - Postprocedural hemorrhage of a musculoskeletal structure following other procedure
      - R58 - Hemorrhage, not elsewhere classified

11. DVT
    - *ICD-9*:
      - 453
    - *ICD-10*:
      - I82.210 - Acute embolism and thrombosis of superior vena cava
      - I82.220 - Acute embolism and thrombosis of inferior vena cava
      - I82.401 - Acute embolism and thrombosis of unspecified deep veins of right lower extremity
      - I82.402 - Acute embolism and thrombosis of unspecified deep veins of left lower extremity
      - I82.403 - Acute embolism and thrombosis of unspecified deep veins of lower extremity, bilateral
      - I82.409 - Acute embolism and thrombosis of unspecified deep veins of unspecified lower extremity
      - I82.411 - Acute embolism and thrombosis of right femoral vein
      - I82.412 - Acute embolism and thrombosis of left femoral vein
      - I82.413 - Acute embolism and thrombosis of femoral vein, bilateral
      - I82.421 - Acute embolism and thrombosis of right iliac vein
      - I82.422 - Acute embolism and thrombosis of left iliac vein
      - I82.431 - Acute embolism and thrombosis of right popliteal vein
      - I82.432 - Acute embolism and thrombosis of left popliteal vein
      - I82.433 - Acute embolism and thrombosis of popliteal vein, bilateral
      - I82.439 - Acute embolism and thrombosis of unspecified popliteal vein
      - I82.441 - Acute emboliwsm and thrombosis of right tibial vein
      - I82.442 - Acute embolism and thrombosis of left tibial vein
      - I82.443 - Acute embolism and thrombosis of tibial vein, bilateral

- I82.451 - Acute embolism and thrombosis of right peroneal vein
- I82.452 - Acute embolism and thrombosis of left peroneal vein
- I82.462 - Acute embolism and thrombosis of left calf muscular vein
- I82.491 - Acute embolism and thrombosis of other specified deep vein of right lower extremity
- I82.492 - Acute embolism and thrombosis of other specified deep vein of left lower extremity
- I82.4Y1 - Acute embolism and thrombosis of unspecified deep veins of right proximal lower extremity
- I82.4Y2 - Acute embolism and thrombosis of unspecified deep veins of left proximal lower extremity
- I82.4Y9 - Acute embolism and thrombosis of unspecified deep veins of unspecified proximal lower extremity
- I82.4Z1 - Acute embolism and thrombosis of unspecified deep veins of right distal lower extremity
- I82.4Z2 - Acute embolism and thrombosis of unspecified deep veins of left distal lower extremity
- I82.4Z3 - Acute embolism and thrombosis of unspecified deep veins of distal lower extremity, bilateral
- I82.4Z9 - Acute embolism and thrombosis of unspecified deep veins of unspecified distal lower extremity
- I82.611 - Acute embolism and thrombosis of superficial veins of right upper extremity
- I82.612 - Acute embolism and thrombosis of superficial veins of left upper extremity
- I82.613 - Acute embolism and thrombosis of superficial veins of upper extremity, bilateral
- I82.621 - Acute embolism and thrombosis of deep veins of right upper extremity
- I82.622 - Acute embolism and thrombosis of deep veins of left upper extremity
- I82.812 - Embolism and thrombosis of superficial veins of left lower extremity
- I82.90 - Acute embolism and thrombosis of unspecified vein
- T84.86XA - Thrombosis due to internal orthopedic prosthetic devices, implants and grafts, initial encounter
- I74.3 - Embolism and thrombosis of arteries of the lower extremities
- I74.5 - Embolism and thrombosis of iliac artery
- I74.8 - Embolism and thrombosis of other arteries
- I74.9 - Embolism and thrombosis of unspecified artery

12. CVA/Stroke with neurological deficit
    - *ICD-9*:
        - 430-436
    - *ICD-10*:
        - I63.9 - Cerebral infarction, unspecified
        - I63.512 - Cerebral infarction due to unspecified occlusion or stenosis of left middle cerebral artery
        - I63.89 - Other cerebral infarction
        - I63.81 - Other cerebral infarction due to occlusion or stenosis of small artery
        - I63.531 - Cerebral infarction due to unspecified occlusion or stenosis of right posterior cerebral artery
        - I63.511 - Cerebral infarction due to unspecified occlusion or stenosis of right middle cerebral artery
        - I63.411 - Cerebral infarction due to embolism of right middle cerebral artery
        - I63.231 - Cerebral infarction due to unspecified occlusion or stenosis of right carotid arteries
        - I63.232 - Cerebral infarction due to unspecified occlusion or stenosis of left carotid arteries
        - I63.432 - Cerebral infarction due to embolism of left posterior cerebral artery
        - I63.40 - Cerebral infarction due to embolism of unspecified cerebral artery
        - I63.519 - Cerebral infarction due to unspecified occlusion or stenosis of unspecified middle cerebral artery
        - I63.412 -Cerebral infarction due to embolism of left middle cerebral artery
        - I63.532 - Cerebral infarction due to unspecified occlusion or stenosis of left posterior cerebral artery
        - I65.02 - Occlusion and stenosis of left vertebral artery
        - I65.21 - Occlusion and stenosis of right carotid artery
        - I65.22 - Occlusion and stenosis of left carotid artery
        - I65.23 - Occlusion and stenosis of bilateral carotid arteries
        - I65.9 - Occlusion and stenosis of unspecified precerebral artery

- I67.81 - Acute cerebrovascular insufficiency
- I67.82 - Cerebral ischemia
- G45.2 - Multiple and bilateral precerebral artery syndromes
- G45.8 - Other transient cerebral ischemic attacks and related syndromes
- G45.9 - Transient cerebral ischemic attack, unspecified
- I66.01 - Occlusion and stenosis of right middle cerebral artery

13. Limb amputation
    - *ICD-9*:
        - V49
        - 897
        - 84
    - *ICD-10*:
        - Z89.411 - Acquired absence of right great toe
        - Z89.412 - Acquired absence of left great toe
        - Z89.421 - Acquired absence of other right toe(s)
        - Z89.422 - Acquired absence of other left toe(s)
        - Z89.429 - Acquired absence of other toe(s), unspecified side
        - Z89.431 - Acquired absence of right foot
        - Z89.432 - Acquired absence of left foot
        - Z89.439 - Acquired absence of unspecified foot
        - Z89.442 - Acquired absence of left ankle
        - Z89.511 - Acquired absence of right leg below knee
        - Z89.512 - Acquired absence of left leg below knee
        - Z89.519 - Acquired absence of unspecified leg below knee
        - Z89.611 - Acquired absence of right leg above knee
        - Z89.612 - Acquired absence of left leg above knee
        - Z89.9 - Acquired absence of limb, unspecified