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Trends in incidence and complications of ankle arthrodesis and total ankle arthroplasty

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ABSTRACT

Background: Total ankle arthroplasty (TAA) and ankle arthrodesis (AA) are surgical treatment options for end-stage ankle arthritis. Providers should have a current understanding of the overall trends of these procedures as both are frequently used. Thus, the objective of the current study is to assess the trends in utilization, patient characteristics and outcomes after TAA and AA.

Methods: The PearlDiver Mariner database was used to capture patient characteristics and outcomes related to 2,494 patients who underwent TAA and 5,901 patients who underwent AA between 2010 and 2018.

Results: The incidence of TAA increased over the course of the study period ($p<0.001$) while the incidence of AA decreased ($p=0.045$). Length of stay (LOS) following AA significantly increased (3.02 vs 4.50, $p<0.001$) while LOS following TAA significantly decreased (2.78 vs 1.65, $p=0.004$). Furthermore, incidence of infections significantly increased following both procedures (AA 1.7% vs 6.6%, $p=0.004$; TAA 0.8% vs 2.7%, $p=0.008$). In 2018, patients who underwent TAA had a significantly decreased LOS (1.65 vs 4.50, $p<0.001$), risk of major complications (1.5% vs 3.9%, $p=0.042$), risk of any medical complication (7.1% vs 14.9%, $p=0.004$), and risk of infection (2.7% vs 6.6%, $p=0.011$) compared to those who underwent AA.

Conclusions: The present study demonstrates increased utilization of TAA for treatment of end-stage ankle arthritis compared to AA in recent years. Over the time period of this study, infection rates have increased and LOS has decreased for TAA while both infection rate and LOS have increased for AA.

Keywords: AA, Ankle replacement, Time-trends, LOS, Revisions, Infections

INTRODUCTION

In the United States there are an estimated 50,000 new cases of end-stage ankle arthritis every year.[1] Although the incidence of ankle arthritis is dramatically less than in other joints, ankle arthritis continues to be a source of pain and activity limitation comparable to hip osteoarthritis.[2] The most common etiology of end-stage ankle arthritis is secondary to trauma, accounting for approximately 70% of cases.[3] It is estimated that 8.3 per 1,000 Medicare recipients sustain an ankle fracture each year.[4] Initially, ankle arthritis is commonly addressed with conservative modalities including NSAIDs, bracing, selective joint injections, shoe modification, and mechanical offloading.[5] When conservative therapies fail to provide adequate relief, operative management is reasonable to consider, with options including AA and TAA.

Between 2007 and 2013 approximately 35,000 patients underwent AA and approximately 15,000 underwent TAA in the United States.[6] Historically, patients with end-stage ankle arthritis were primarily offered AA due to high failure rates of TAAs.[5,7-9] However, advancements in total ankle implants with improved anatomic design have led to decreased revision rates and an increase in utilization of TAAs over time.[10,11]

Although both procedures have comparable outcomes and 1-year postoperative revision rates, these procedures are not without risks.[7,12,13] Complications of AA include adjacent joint degeneration, gait alteration, and persistent pain.[15] Similarly, ankle arthroplasty can also be complicated by residual pain and a higher risk of revision surgery at five years secondary to implant subsidence, loosening, and infection.[12]

Despite existing trend studies on TAA and tibial talar arthrodesis using nationally representative data, it is essential for providers to be up to date on the current trends and outcomes relevant to these procedures with the expected increase in these operations over time, so appropriately informed decisions can be made.[6,15-17] Furthermore, the landscape of foot and ankle surgery continues to change with the advent of new technology and surgical techniques; thus an updated analysis would be beneficial for surgeons. The objective of the current study was to assess the updated trends in utilization, patient characteristics and outcomes after TAA and AA in the U.S. using a national database sample from 2010-2018. We hypothesize that over this time period, (a) the utilization rates of TAA have increased, and (b) outcomes have improved: i.e., length of hospital stays, rates of complications, and rates of revisions have decreased.

METHODS

Database

The data for the present study was collected from a publicly available, subscription-based database of patients, the PearlDiver Mariner records database (PearlDiver Inc., Colorado Springs, Colorado, USA; www.pearldiverinc.com). The database contains procedural volumes and demographic information for patients with international classification of diseases, 9th revision (ICD-9) and 10th revision (ICD-10) diagnoses and procedures or current procedural terminology (CPT) codes. Revision was defined as a return to the operating room after index procedure. The PearlDiver dataset contains records of 30 million patients across all payer types (commercial, Medicare, Medicaid, government, and cash) in the entire United States from 2010 to 2018, searchable by billable codes. The database was stored on a password-protected computer server maintained by PearlDiver. ICD and CPT codes can be searched separately or in combination, and searches yield cohorts of patients with the searched code or combination of codes. This data is deidentified and was deemed exempt by institutional review board at our institution.

Study group and outcome of interest

Patients from 2010-2018 undergoing primary AA and TAA (Table 1) were queried. There was no specific sampling technique to determine the sample size. The data from all patients fitting the inclusion criteria of undergoing an AA or TAA from 2010 to 2018 were included. The inclusion criteria were patient that underwent the described procedures during that time period. Total patient volumes and patient demographics (age, gender) were assessed at each year from 2010 to 2018. Number of surgeries performed in the outpatient setting were also identified using service location modifiers. These surgeries were confirmed as outpatient surgeries by excluding patients with LOS than zero. LOS, postoperative complications within 90 days of surgery, and revisions within one year of surgery were also queried. 90-day major medical complications included pulmonary embolism (PE), pneumonia (PNA), myocardial infarction (MI), cerebrovascular accident (CVA), sepsis, and death. All 90-day complications encompassed the major complications as well as deep vein thrombosis (DVT), acute kidney injury (AKI), urinary tract infection (UTI), blood transfusion, and wound complications. Infection within 90 days of index surgical procedure was also assessed. The pearldiver database defines surgical site infection as

ICD-10 codes of deep and superficial infections (e. g., ICD-10-D-T8130XA, ICD-10- D-T8130XD, ICD-10-D-T8130XS, ICD-10-D-T8131XA, ICD-10-D-T8132XD) and hardware infections (ICD-10-DT8463XA, ICD-10-D-T8463XD, ICD-10-D-T8463XS). These diagnosed infections lead to the treatment with antibiotics.

Data analysis

Overall procedural volume data are reported as number of patients with the given CPT in the database output in a given year. Normalized incidences were calculated as the number of patients with the procedure in a given year divided by the number of patients in the database in a given year. Complication rates are reported as percentages of the patient population with the complication of interest. Trends over time were calculated using a linear regression analysis. The incidence of complications from 2010 and 2018 were compared between AA and ankle arthroplasty using Student t-test and chi-squared analyses. $P<0.050$ was considered significant for the study. All statistical analyses were performed in both SPSS version 24 (Aramonk, NY) and Microsoft excel (Microsoft, Redmond, WA).

RESULTS

From 2010 to 2018, an initial cohort of 8,395 (N) patients were included, of which 29.7% (n=2,494) underwent TAA and 70.2% (n=5,901) underwent AA. The average age of patients undergoing AA was 57.1 years ±13.43 (median=59) and 51% (n=3,002) were female sex. The average age of patients undergoing TAA was 62.9 years±10.34 (median=64) and 52% were female.

Population incidence

The population-normalized incidence of patients undergoing AA decreased significantly over time ($p=0.045$) (Table 1). The normalized incidence per 1 million beneficiaries decreased from 33.1 in 2010 to 25.9 in 2018. Conversely, the incidence of patients undergoing TAA increased over the same time period, from 6.6 patients per 1 million beneficiaries to 16.1 (p<0.001) (Table 2) (Figure 1).

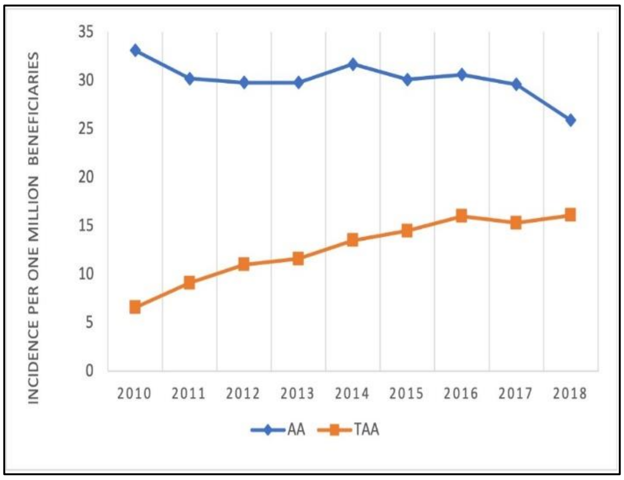

Figure 1: Utilization of AA and TAA from 2010-2018.

Surgical and patient demographics

The average age of patients undergoing AA and TAA was significantly older in 2018 compared to 2010 increasing from 56.8 to 58.1 years and 60.4 to 63.9 years, respectively (p=0.022, p=0.030, respectively). AA performed in the outpatient setting increased from 39.1% of cases in 2010 to 61.3% in 2018 (p<0.001).

Similarly, the percentage of patients undergoing outpatient TAA increased from 15.1% in 2010 to 30.0% in 2018 (p<0.001) (Tables 1 and 2).

LOS

The LOS (days) following AA increased significantly from 2010 to 2018 (3.02±2.53 vs 4.50±4.29, p<0.001) and the LOS following TAA decreased significantly in the same time period (2.78±3.99 vs 1.65±1.01, p=0.004) (Tables 1 and 2).

Complications

The incidence of infection within 90 days following both surgical procedures increased significantly over time between 2010 and 2018 (AA 1.7% vs 6.6%, p=0.004; TAA 0.8% vs 2.7%, p=0.008). Rates in 90-day major complications and one-year revision rate did not change following either surgical procedure over the study period (p>0.050). When compared together, in 2010 patients undergoing TAA had a lower rate of medical complications (11.4% vs 20.8%, p=0.011) and revisions (2.3% vs 7.1%, p=0.047) than patients undergoing AA (Table 3).

Likewise, in 2018 patients undergoing TAA had significantly decreased LOS (1.65 vs 4.50, p<0.001), risk of major complication (1.5% vs 3.9%, p=0.042), any medical complication (7.1% vs 14.9%, p=0.004), and infection rate (2.7% vs 6.6%, p=0.011) compared to AA (Table 3).

Revisions

The incidence of revision at 1 year decreased over time for both AA and ankle arthroplasty. During the study period, for AA rate of revision at 1 year decreased from 7.1% in to 2010 to 4.6% in 2018 (p=0.85). During the study period, for ankle arthroplasty increased from 2.3% in 2010 to 2.4% in 2018 (p=0.07).

Table 1: Patient demographics and complications following AA.

Variables	2010	2011	2012	2013	2014	2015	2016	2017	2018	P value
Total patients	662	639	634	672	720	677	695	660	542	0.492
Per 1,000,000 beneficiaries	33.1	30.2	29.8	29.8	31.7	30.1	30.6	29.6	25.9	0.045
Age (in years)	56.8± 12.8	56.1± 12.9	56.9± 13.3	57.2± 13.6	57.1± 13.7	56.7± 13.3	56.9± 14.0	58.5± 13.5	58.1± 13.8	0.022
Gender (F)	339 (51.2%)	323 (50.5%)	323 (50.9%)	347 (51.6%)	357 (49.6%)	353 (52.1%)	369 (53.1%)	327 (49.5%)	264 (48.7%)	0.483
Outpatient	259 (39.1%)	233 (36.5%)	257 (40.5%)	306 (45.5%)	382 (53.1%)	359 (53.0%)	359 (51.7%)	376 (57.0%)	332 (61.3%)	<0.001
LOS*	3.02± 2.53	3.03± 3.51	3.58± 5.21	3.48± 4.28	3.38± 2.85	3.62± 4.15	3.62± 3.75	4.03± 4.75	4.50± 4.29	<0.001
Major complication*	35 (5.3%)	29 (4.5%)	28 (4.4%)	29 (4.3%)	42 (5.8%)	44 (6.5%)	32 (4.6%)	40 (6.1%)	21 (3.9%)	0.849
Any complication*	138 (20.8%)	109 (17.1%)	92 (14.5%)	95 (14.1%)	146 (20.3%)	118 (17.4%)	108 (15.5%)	107 (16.2%)	81 (14.9%)	0.296
Infection*	11 (1.7%)	12 (1.9%)	7 (1.1%)	8 (1.2%)	20 (2.8%)	19 (2.8%)	56 (8.1%)	50 (7.6%)	36 (6.6%)	0.004
Revision#	47 (7.1%)	31 (4.9%)	37 (5.8%)	40 (6.0%)	46 (6.4%)	42 (6.2%)	44 (6.3%)	48 (7.3%)	25 (4.6%)	0.850

*LOS; Length of stay, *Complication within 90 days of surgery and #Complication within one year of surgery.

Table 2: Patient demographics and complications following TAA.

Variables	2010	2011	2012	2013	2014	2015	2016	2017	2018	P value
Total patients	132	193	235	261	306	325	364	341	337	<0.001
Per 1,000,000 beneficiaries	6.6	9.1	11.0	11.6	13.5	14.5	16.0	15.3	16.1	<0.001
Age (in years)	60.4± 11.4	60.5± 10.7	62.5± 10.2	62.4± 10.2	63.8± 9.5	63.2± 9.9	63.3± 10.3	63.3± 10.4	63.9± 10.5	0.003
Gender (F)	72 (54.5%)	107 (55.4%)	137 (58.3%)	133 (51.0%)	160 (52.3%)	154 (47.4%)	170 (46.7%)	179 (52.5%)	185 (54.9%)	0.269
Outpatient surgery	20 (15.2%)	36 (18.7%)	47 (20.0%)	54 (20.7%)	51 (16.7%)	68 (20.9%)	83 (22.8%)	75 (22.0%)	101 (30.0%)	<0.001
LOS	2.78± 3.99	2.44± 1.67	2.18± 1.14	2.59± 2.35	2.15± 1.31	2.17± 1.24	1.96± 1.28	2.14± 1.63	1.65± 1.01	0.004
Major complication*	5 (3.8%)	10 (5.2%)	3 (1.3%)	6 (2.3%)	23 (7.5%)	6 (1.8%)	6 (1.6%)	6 (1.8%)	5 (1.5%)	0.271
Any complication*	15 (11.4%)	27 (14.0%)	19 (8.1%)	26 (10.0%)	46 (15.0%)	39 (12.0%)	28 (7.7%)	30 (8.8%)	24 (7.1%)	0.167
Infection*	1 (0.8%)	2 (1.0%)	0 (0.0%)	2 (0.8%)	7 (2.3%)	9 (2.8%)	9 (2.5%)	16 (4.7%)	9 (2.7%)	0.008
Revision#	3 (2.3%)	3 (1.6%)	4 (1.7%)	5 (1.9%)	6 (2.0%)	7 (2.2%)	8 (2.2%)	11 (3.2%)	8 (2.4%)	0.070

LOS; Length of stay, *Complication within 90 days of surgery and #Revision within one year of initial surgery.

Table 3: Comparison of complications and trends between AA and TAA.

Variables		AA	TAA	AA vs TAA, p value
2010	LOS	3.02±2.53	2.78±3.99	0.373
	Major complication*	35 (5.3%)	5 (3.8%)	0.662
	Any medical complication*	138 (20.8%)	15 (11.4%)	0.011
	Infection*	11 (1.7%)	1 (0.8%)	0.702
	Revision#	47 (7.1%)	3 (2.3%)	0.047
2018	LOS	4.50±4.29	1.65±1.01	<0.001
	Major complication*	21 (3.9%)	5 (1.5%)	0.042
	Any medical complication*	81 (14.9%)	24 (7.1%)	0.004
	Infection*	36 (6.6%)	9 (2.7%)	0.011
	Revision#	25 (4.6%)	8 (2.4%)	0.102
Overall trends (2010 to 2018)	LOS			<0.001
	Major complication*			0.253
	Any medical complication*			0.703
	Infection*			0.089
	Revision#			0.320

*Complication within 90 days of surgery, #Revision within one year of initial surgery and *LOS; length of stay.

DISCUSSION

TAA and AA are both effective treatments for the management of end-stage ankle arthritis. As the popularity of TAA increases secondary to improvements in implant design and surgeon comfort with the procedure, it is important for providers to have a current understanding of its risk and benefits relative to AA.[10,11] From 2010 to 2018, the incidence of TAA increased while LOS decreased and infection rate increased. Over same time period incidence of AA decreased while LOS and the infection rate increased.

From 2010 to 2018, the yearly incidence of AA decreased from 33.1/1,000,000 to 25.9/1,000,000, a decrease of 22%. During the same time period, the yearly incidence of TAA increased from 6.1/1,00,000 to 16.6/1,000,000, an increase of 172%. This overall increase in TAA over time is consistent with trends seen in prior studies which looked at earlier time points.[6,16] The decrease in AA overtime is likely related to the expanded indications for TAA, with more patients undergoing TAA instead of AA. With regards to demographics, the average age of patients undergoing TAA and AA both significantly increased from 60.4 to 63.9 years and 56.8 to 58.1 years, respectively. This is likely a reflection of the steady rise in life expectancy of the general population and the overall growing population of Americans aged 65 years and older.[18] Elderly patients who sustain ankle fractures were previously more likely to be managed conservatively, but nonoperative management has been associated with increased morbidity due to the development of post-traumatic arthritis. As a result, older patients and those with more comorbidities have increasingly become operative candidates resulting in decreased incidence of post-traumatic arthritis.[19]

A variety of factors may explain the shift towards a higher frequency of TAAs. As implant designs have improved and mechanical failures have decreased, surgeon comfort with these procedures has also increased.[10,11,20] Although failure rates from TAA have previously been reported to range between 7-20% at 5 year follow up, more recent studies show that revision rates secondary to subsidence and loosening have declined.[7,10,17,21] Our data showed one year revision rates of TAA ranging from 1.6-3.2% and did not significantly change over the study period. Similarly, revision rates for AA did not significantly change and were comparable to those seen in previous studies.[10,12,22]

As a result of improved outcomes and declining revision rates, outpatient surgery has become increasingly popular in foot and ankle surgery because of its cost effectiveness and patient convenience. In the current study, the frequency of both outpatient TAA and AA significantly increased from 2010 to 2018 from 15.2% to 30.0% and 39.0% to 61.3%, respectively. “Outpatient” surgery was defined by the database to mean patients being discharge the same day of their surgery. This is likely a reflection of improved techniques in perioperative analgesia including pain catheters and nerve blocks that promote earlier mobility and accelerate discharge to home. Consequently, LOS was also expected to decline. As expected, LOS for TAAs significantly decreased from 2.78 to 1.65 days. Traditionally, TAA was performed in the inpatient setting with a 1-2 night postoperative hospital stay to provide patients with wound care, pain control and physical therapy.[23] Several studies have demonstrated that outcomes and perioperative complications are similar between both inpatient and outpatient ankle surgery.[23-26] This was consistent with the current study as the rate of revision surgery and any medical complication remained largely unchanged in the even in the setting of increased frequency of outpatient surgery for both AA and TAA. Interestingly, LOS for AA significantly increased from 3.0 to 4.5 days. This may be related to patient selection as patients with more medical comorbidities who are not candidates for TAA are more likely to be treated with AA.[6] This patient selection factor likely contributes to the differences in medical complications found in this study, as patients with more comorbidities such as diabetic neuropathy are not good candidates for TAA due to lack of protective sensation. These patient populations are at risk for elongated hospital stays due to challenges with mobility and perioperative medical optimization such as glycemic control prior to being cleared for discharge. Our study, does not have data comparing patient demographics between the TAA and AA population, but the differences in LOS can be likely by attributes the differences in patient population undergoing these procedure and previous risk factors. This further explains the increase in LOS as patients with fewer comorbidities have become candidates for TAA at end of study period compared to the beginning.

Similar to trends in LOS, overall major complications and medical complications were less in the TAA than in the AA group. This is likely a reflection in differences in patient comorbidities before surgery. As more medically complex patients, particularly those with diabetes or low demand patients, make up a greater proportion of the patient population undergoing AA.

Interestingly, rates of infection significantly increased over time for both AA and TAA. Previous studies have shown that the anterior incision required for TAA creates a wound that is especially prone to complications and surgical site infection due to thin skin and low muscle bulk.[27] Despite this fact, the AA infection rate was higher than TAA, which was consistent with prior studies.[22,28] This is reasonable to expect, as mentioned previously, complications such as infection are associated with the need for surgical revision after ankle arthroplasty.[29] Diabetes has also been associated with higher infection risk after both AA and TAA.[30] In addition, older age is associated with increased risk of infection in both AA and TAA, likely secondary to higher comorbidities.[29,31] Data from Medicare estimates report that a quarter of all patients above the age of 65 have at least 4/more chronic health problems.[32] Furthermore, another consideration for increasing rate of infection could be patients receiving fewer doses of periop antibiotics as both AA and TAA procedures are increasingly being performed as outpatient procedures. However, prior studies have shown similar rates of surgical site infections when comparing inpatient and outpatient ankle surgeries so this would require further investigation.[26,33] Furthermore, increase in infection rate can also be reflective of improved documentation in medical record over time.[34] Additionally, there is evidence to suggest that overall AA and TAA are being done on more medically complex patients with higher overall rates of obesity and diabetes and at higher overall risk for infection.[15] Another reason in the rise of overall infections could also be provider related. Both podiatrist and orthpaedic foot and ankle surgeons are trained in these techniques. There is evidence that demonstrates podiatrist are doing greater portion of AA and TAA cases over time. This trend has been associated with increase patient LOS and cost and overall inferior outcomes.[35]

Limitations

There are several limitations to this study, including those inherent in retrospective large database research. The analysis of administrative data is only as accurate and complete as the data that are coded. Inaccuracies in coding by the provider or billing personnel can cause potential errors in the data and conclusions in this study. Although coding errors are a potential limitation, the overall error rate is likely to be acceptably low. A 2016 report by the CMS showed an overall coding error rate of 1.1% for the database used in this study. Another limitation is that we were unable to query surgeon volume and technique as surgeon experience with these procedures can influence outcomes. The PearlDiver database is unable to provide data on level of surgeon experience or if they are fellowship trained. In addition, the type of surgical approach used for these procedures could not be elucidated. Previous studies have demonstrated no significant difference in infection rates when TAA was done through an anterior or lateral transfibular approach. Another limitation is reporting of technique with arthrodesis as arthrodesis can be performed both arthroscopically and open. There is evidence that difference in technique can influence outcomes are arthrodesis, as open surgery is associated with high rate of complications.

Furthermore, we did not query based on socioeconomic disparities, which have been associated with inferior outcomes in orthopaedic surgery, which is a limitation of the study. Another limitation is related to revisions as the database is unable to provide information for reason for reoperation. Another limitation in this study is that variations in patient comorbidities may influence trends in utilization and outcomes following the surgical procedures. Unfortunately, we were unable to query the database for rates of diabetes or smoking history within each subgroup. For example, diabetes has been associated with higher infection risk after both AA and TAA. In addition, information regarding surgeon training may be a limitation. Due to the limitations of the database we are also unable to provide differences in outpatient vs inpatient surgery. There is variability to postoperative protocols between institutions. One can reasonable expect patients have surgery in the inpatient setting receive more doses of perioperative antibiotics compared to patients discharged same day from surgery. This would expected to influence infection rates as well. Furthermore, due to the limitations of the database we were unable to stratify if the AA being performed were open or arthroscopic, which is important to note as it would influence infection rates and rates of nonunion/malunion. Despite these limitations, this study provides a comprehensive update on the landscape of these common procedures in foot and ankle surgery.

CONCLUSION

For treatment of end-stage ankle arthritis, the incidence of TAA continues to increase from 2010-2018. The study findings also demonstrate that over the included period of this study, TAA is associated with decreasing LOS and increasing infection rate while rates of revision and complications have remained unchanged. For patients undergoing AA, both infection rate and LOS increased from 2010 to 2018, while rates of revision and complications also remained unchanged.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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