Department of Surgery

Preliminary Report of a Hybrid Total Ankle Arthroplasty Combining a Stemmed Intramedullary Tibial Component With Chamfer-Cut Talar Dome.

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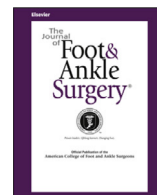
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ABSTRACT

Total ankle arthroplasty (TAA) is a viable treatment for end-stage ankle arthritis. In our experience, a stemmed intramedullary tibial component combined with a chamfer-cut talar component provides the most stable construct for TAA. We present our technique for placement of this hybrid prosthesis utilizing the INBONE tibial component in combination with the INFINITY talar component. This technique differs from the standard protocol by minimizing use of both patient-specific and standard intraoperative guides. The primary aim of this study is to report our preliminary outcomes with our novel technique. Secondarily, we aim to demonstrate that placement of this hybrid prosthesis is radiographically reproducible and accurate. The first 10 patients undergoing this technique with at least 1 year of follow-up were retrospectively reviewed. Average visual analog pain scale decreased from 7.4 preoperatively to 0.5 at 1 year postoperatively. The average time to weightbearing was 6.4 weeks. Complications were minimal, and no implant-related complications were encountered. First weightbearing ankle radiographs postoperatively were evaluated by 3 reviewers to determine accuracy of the tibial intramedullary stem in relation to the anatomical axis of the tibia. We found that the deviation of the tibial implant from the anatomic axis was on average $0.9° \pm 0.5°$ in the coronal plane, and $2.2° \pm 2.7°$ in the sagittal plane. Inter-rater reliability was 83%. We conclude that this hybrid technique utilizing a stemmed intramedullary tibial component in combination with a chamfer-cut talar component for TAA is reproducible, accurate, and safe.

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End-stage arthritis of the ankle affects approximately 1% of the population. While less common than arthritis of the hip and knee, ankle arthritis can be just as painful and debilitating (1). Further, unlike arthritis of the hip and knee, the most common etiology of end-stage ankle arthritis is post-traumatic (56%-80%) thereby affecting a significantly younger population, often with complex deformities. The complexity of these cases frequently requires adaptive solutions (2,3). Over the past 15 years, the plethora of worldwide literature supports the acceptance of total ankle arthroplasty (TAA) as a viable alternative to ankle arthrodesis for end-stage ankle arthritis (4-6).

At the time of this writing, 7 primary and 3 revision ankle replacement systems are currently available for implantation in the United States (7). Mid-term outcomes with the INBONE implant have shown high survivorship rates with few tibial stem complications compared to the higher possibility of talar component subsidence (8-10). Alternatively, the INFINITY prosthesis has mechanically stabilizing chamfer cuts associated with its talar component, which removes less bone from the talus than the INBONE talar component, potentially leading to lower rates of talar component complications. However, concerns regarding early tibial component loosening with injudicious use of the INFINITY system have been raised (11,12).

The INBONE and INFINITY total ankle systems are compatible in design. The INFINITY system has even been marketed as featuring an interchangeable talar component, which would allow for the INBONE flat-top talar component to be combined with the INFINITY tibial component (13,14). To our knowledge, however, there has been no prior report combining the INBONE tibia and INFINITY talus components for TAA despite similar compatibility.

Longevity and survivorship of total ankle implants may depend on accurate component alignment (15-17). With the advent of preoperative navigation systems, such as PROPHECY, it is possible to plan the position of these implants preoperatively. The position is then obtained intraoperatively with patient-specific guides for both the tibia and talus. For the tibial component, the INBONE implant is intended most frequently to be placed parallel to the anatomic axis of the tibia (15). Previous studies have shown that accurate placement of the INBONE tibial stem can be within 2° to 5° of the intended implant position with the use of patient-specific guides (15,18,19).

TAA systems have intricate standardized instrumentation to achieve accurate implant placement, such as the C-bracket and leg holder in the systems utilized in this study. Consequently, only conventional C-arm may be used with such instrumentation for intraoperative fluoroscopy. Anecdotally, many surgeon's find this to be a major disadvantage when it would be preferable to use the more compact and safer mini-C-arm.

The purpose of this study is to report our hybrid technique that combines a stemmed intramedullary tibial component (INBONE™ Total Ankle System, Wright Medical Technology, Memphis, TN) with a chamfer-cut talar component (INFINITY™ Total Ankle System, Wright Medical Inc., Memphis, TN) for TAA. This novel technique minimizes the need for intraoperative instrumentation, which enables the use of a mini-C-arm. We report our preliminary outcomes in the first 10 patients who underwent this technique. Primary outcomes include visual analog pain scale (VAS), time to weightbearing, and associated complications. Due to the minimal use of intraoperative instrumentation used with this technique, a secondary aim of this study was to determine the radiographic accuracy of tibial stem placement postoperatively. The secondary outcome measure was deviation of the intramedullary tibial stem from the tibial anatomic axis on first weightbearing radiographs.

Patients and Methods

Study Population

After obtaining institutional review board approval, the first 10 consecutive patients undergoing this hybrid technique for TAA with at least 1 year of postoperative follow-up were identified and retrospectively reviewed. The patient cohort consisted of 5 males and 5 females with a mean age of 62.5 (range 40-84) years. The average body mass index was 27.6 kg/m². The underlying etiology for ankle arthritis preoperatively was predominantly post-traumatic osteoarthritis, which accounted for 80% of patients with primary osteoarthritis as the cause in the remaining 20%. Eight out of the 10 patients in our cohort presented with a deformity of the ankle. Of these, 6 had a varus deformity, and 2 had a valgus deformity. Three patients presented with a moderate to severe deformity (defined as ≥10° of either ankle varus or valgus). The most common comorbidities seen in our patient population were hypertension, hyperlipidemia, hypothyroidism, and depression. Patient demographics are summarized in Table 1. All patients underwent preoperative computed tomography (CT) scan utilizing a standard protocol for preoperative navigation (PROPHECY™ INBONE™ Preoperative Navigation System, Wright Medical Technology, Memphis, TN). The preoperative navigation report recommended utilizing the anatomic axis over the mechanical axis for tibial implant placement in both the sagittal and coronal planes for all but 1 patient who presented with a severe proximal tibia deformity from prior trauma. The recommendation from the preoperative navigation report for this patient was to split the difference between the mechanical and anatomic axes in the coronal plane, and to utilize the anatomic axis in the sagittal plane. All procedures were performed by the senior author, P.B.

Operative Technique

The patient is placed in the supine position on the operating room table under general anesthesia. A thigh tourniquet is used for hemostasis. The patient is prepped and draped in the usual sterile fashion. An approximately 15 cm incision is placed midline over the anterior ankle. The extensor retinaculum is incised 1 to 2 cm lateral to skin incision to maintain coverage of the tibialis anterior tendon. Deep dissection down to the joint capsule is initiated between the tibialis anterior and extensor hallucis longus tendons. The neurovascular bundle is mobilized laterally. Care is taken to use minimal retraction throughout the procedure (Fig. 1).

Table 1

Preoperative patient demographics (N = 10)

Characteristic	Value*
Sex	
Male	5 (50%)
Female	5 (50%)
Age, yr	62.5 (40-84)
BMI, kg/m²	27.6 (25-34.6)
Arthritis etiology	
Post-traumatic	8 (80%)
Primary osteoarthritis	2 (20%)
Deformity	
Varus	6 (60%)
<10°	5 (83.33%)
≥10°	1 (16.67)
Valgus	2 (20%)
<10°	0 (0%)
≥10°	2 (100%)
None	2 (20%)
Comorbidities	
Hypertension	6 (60%)
Hyperlipidemia	3 (30%)
Hypothyroidism	2 (20%)
Depression	2 (20%)
Atrial fibrillation	2 (20%)
Type II diabetes	1 (10%)
Chronic kidney disease	1 (10%)
COPD	1 (10%)

Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease.

  * Values in No. (%) or mean (range).

Bone Resection

Tibial Alignment Guide & Tibial Bone Resection

The periosteum is stripped from the anterior tibia and the tibial alignment guide produced from preoperative navigation is applied. Adequate positioning and alignment of the guide in line with the anatomical axis of the tibia was checked under fluoroscopy with the use of the Hologic Fluoroscan Insight Mini C-arm (Hologic Inc, Marlborough, MA). The alignment guide is utilized for placement of the 2 tibial Steinmann pins. Proper anteroposterior (AP) and lateral view calibration is then achieved fluoroscopically. In the AP view, this occurs when the tibial guidewires appear as 2 dots. Correct lateral view is confirmed when the 2 wires appear as one. After fluoroscopic calibration, the tibial alignment guide is removed. The predetermined sized resection guide is placed over the 2 pins with an additional 2 pins placed for stability. The antirotation notch is drilled, followed by the tibial bone cuts proximally, medially, and laterally with the oscillating saw. The bone is then carefully removed (Fig. 2).

Soft Tissue Balancing & Talar Bone Cut

Talar alignment is assessed. Soft tissue balancing is then performed if there is any coronal plane malalignment. With the talus now congruent in the ankle mortise, a 3 to 4 mm wafer of bone is removed from the talar dome. This is completed with the foot held at 90° to the leg to ensure that the talar dome resection is parallel to the previously cut tibia. After removal, the wafer is inspected to confirm equivalent resection in all planes (Fig. 3).

Tibial Stem Placement

Alignment Guidewire

Utilizing anatomical landmarks, a trocar-tipped guidewire is then placed freehand starting in the plantar heel anterior to the subcalcaneal fat pad and slightly lateral to the midline. This precludes the use of the standardized instrumentation for achieving proper stem alignment. The wire is then advanced through the calcaneus and talus while aiming for the antirotation notch in the tibia to achieve coronal plane alignment. Concurrently, lateral projection fluoroscopic images confirm proper alignment in the sagittal plane most commonly utilizing the bisection of the lateral process of the talus. As the guidewire is advanced into the tibia, fluoroscopy should be utilized to verify the proper central alignment in a medial to lateral direction and an anterior to posterior direction using a mini-C-arm.

Utilization of the C-bracket from the patient-specific alignment guide was initially attempted; however, with minimal bone resected from the talus, this resulted in poor seating of the jig within the joint. This led to the guide wire being inadequately aligned in
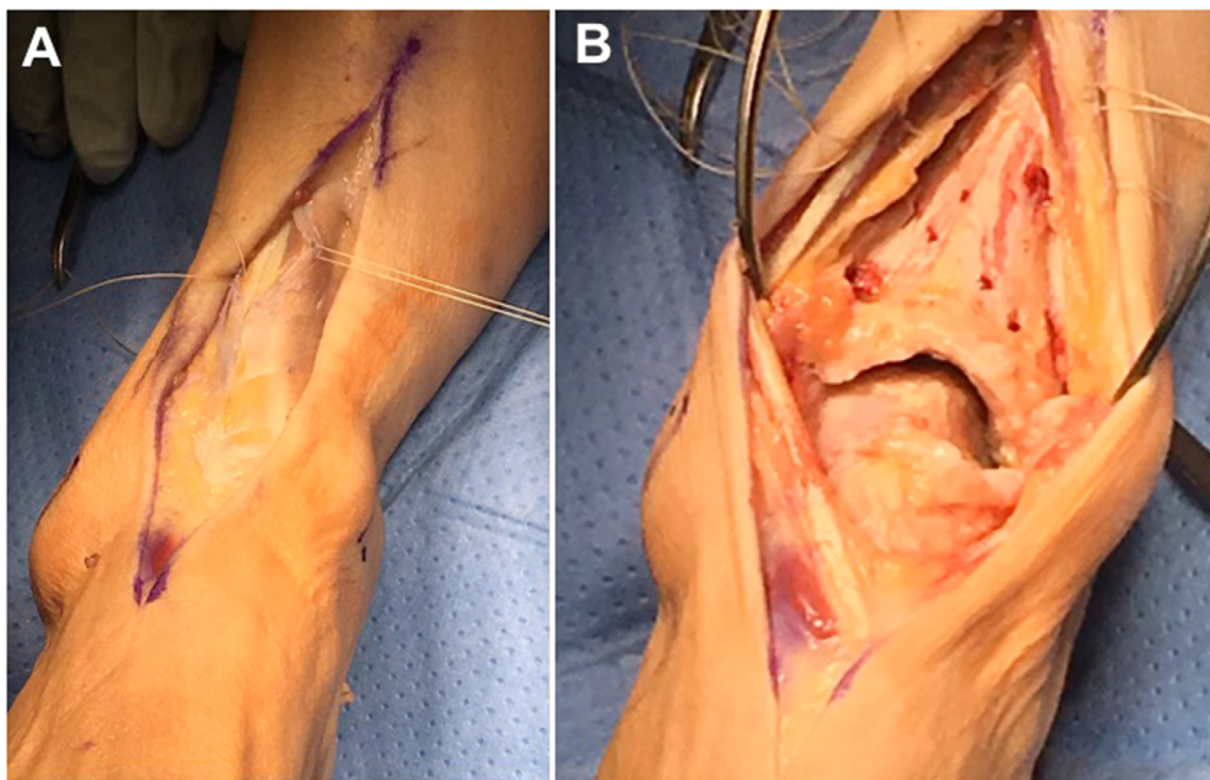
Fig. 1. Incision placement and soft tissue dissection. (*A*) The incision is approximately 15 cm in length and performed midline on the anterior leg and foot. The retinaculum may be tagged for later repair as shown here. (*B*) Deep dissection is performed between the tibialis anterior and extensor hallucis longus tendons and the periosteum is stripped from the anterior tibia for appropriate placement of the PROPHECY INBONE tibial alignment guide.

relation to the anatomic axis and provided the impetus to begin utilizing our aforementioned freehand technique (Fig. 4).

Tibial Drilling & Reaming

Once the guidewire is properly positioned, a cannulated 6-mm drill is introduced over the guidewire after making a stab incision on the plantar heel. The drilling is performed into the distal third of the tibia while checking AP and lateral views for correct coronal and sagittal alignment under fluoroscopy. The drill and guidewire are then removed. Reaming of the tibial medullary canal in all cases, starts with the smallest (12 mm) reamer. Reamer diameter is increased in accordance with the preoperative plan and expected stem sizes. Reaming is performed carefully by hand with the reamers under fluoroscopic guidance. While not utilized with the initial 10 patients reported in this study, further streamlining of this technique has led to the use of sharp reamers to enable this to be performed more easily by hand. This allows for fine alignment adjustments to be made in both the coronal and sagittal planes if needed (Fig. 5).

Tibial Stem and Tray Insertion

The tibial tray trial is then introduced. Complete anterior to posterior coverage is confirmed with fluoroscopy. Next, the stem components and tibial tray are inserted into the tibia utilizing standard surgical technique for a stemmed intramedullary tibial component.

Talar Component Placement

Focus is now shifted to the talus. Communication with the implant manufacturer confirmed that the polyethylene (poly) components for the 2 implant systems were compatible with each other. Poly trials are placed sequentially into the tibial tray along with the predetermined size talar dome trial. Final selection of the poly size is often determined intraoperatively. It may be necessary to perform a gastrocnemius lengthening at this time to correct any equinus deformity or to accommodate a thicker poly. Once adequate coverage of the talus is confirmed with fluoroscopy, the talar dome guide pins are placed, and the trial is removed. Standardized surgical technique is followed here to perform the anterior and posterior chamfer cuts and placement of the talar dome. Insertion of the poly follows the standard technique for the stemmed intramedullary tibial component.

The tourniquet is released prior to closure to allow for tissue reperfusion. Layered anatomic closure utilizing absorbable suture is performed in the capsule, retinaculum, and subcutaneous tissues. Nylon suture is used in the skin. A sterile dressing and posterior splint are then applied. Our typical postoperative protocol involved non-weightbearing in a posterior splint for 3 weeks, followed by partial weightbearing for an additional 2 to 3 weeks in a walking boot. Once the patient is able to tolerate full weightbearing in a walking boot, they are gradually transitioned to a regular sneaker. Physical therapy is typically implemented at 4 to 6 weeks postoperatively.

Data Collection

The patient-reported VAS was collected for all patients at the following time points: preoperatively, 1 month postoperatively, 3 months postoperatively, 6 months postoperatively, and 1 year postoperatively. Collection of the VAS consisted of a scale measuring 10 cm in length with 0 and 10 marked on either end of the scale. The scale was given to the patient prior to his/her scheduled appointment. The patient was asked to place a single line mark on the scale to indicate the amount of pain he/she is in on average. These data were then measured.

Time to weightbearing in a regular sneaker was recorded. Complications were also reviewed and graded based on the Glazebrook classification (20). Intraoperative characteristics, such as fluoroscopy exposure time, radiation dose, tourniquet time, and operative time were also collected. Dose area product was used as a measure of radiation dose and is a common method of comparing radiation usage with fluoroscopy (21).

Radiographic Analysis

First postoperative weightbearing ankle AP and lateral radiographs for each of the 10 patients were assessed by 3 blinded evaluators (P.B., S.M., and J.C.). The anatomical axis was determined using previously described methods (15,18). A line through the center of the tibial stem component was then made. The angle between the 2 lines was measured to determine the implant's deviation from the anatomical axis in both the coronal (AP view) and sagittal (lateral view) planes. Representative examples of this analysis can be seen in Fig. 6 alongside preoperative radiographs and the preoperative navigation report. Based on prior studies, acceptable deviation of the tibial stem from the anatomical axis was determined to be less than 5°; however, less than 2° is ideal (15,18,19).
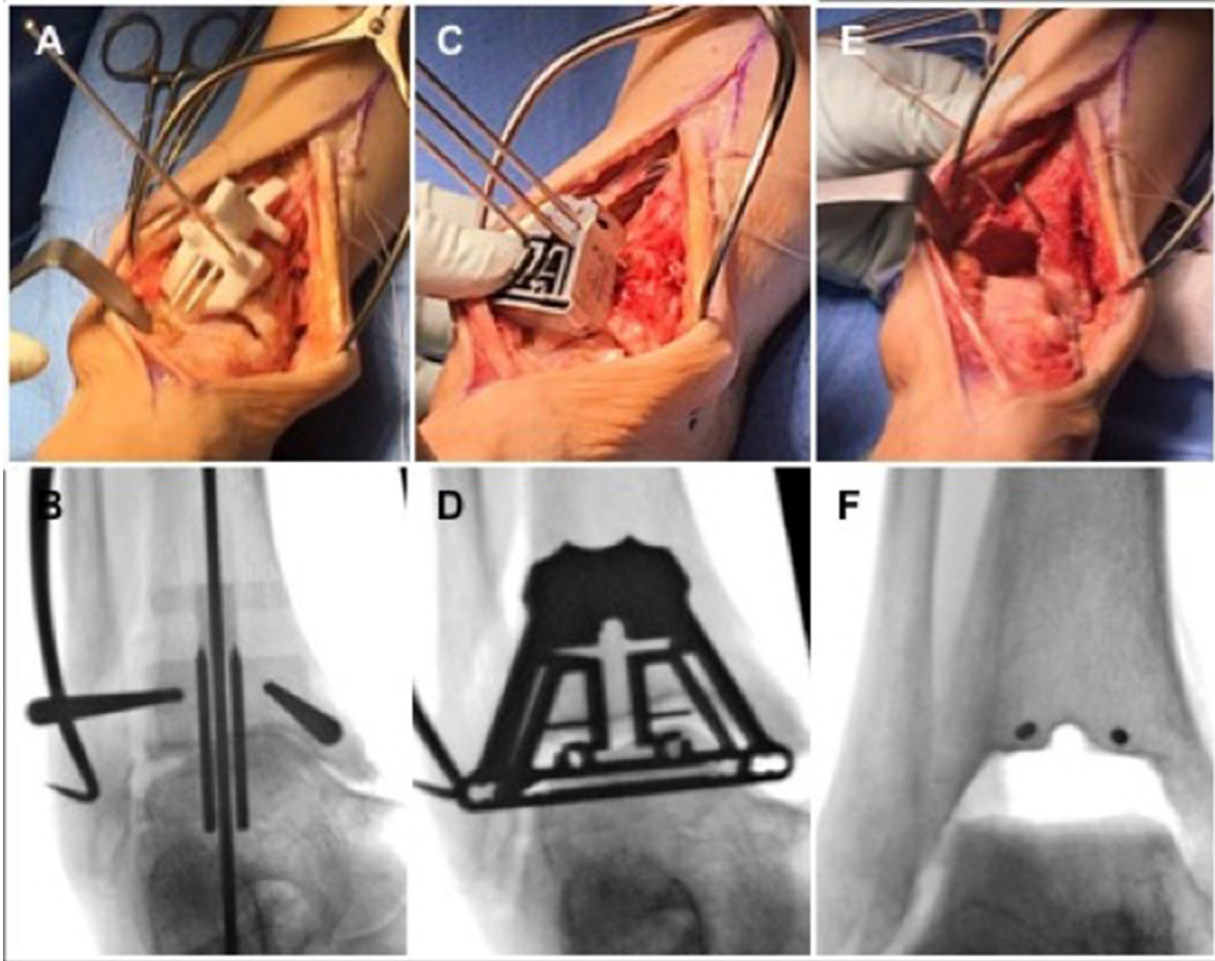
Fig. 2. Placement of PROPHECY INBONE tibial alignment guide enabling tibial bone resection. (*A, B*) The alignment guide and Steinmann pins are placed in the tibia, which is checked with fluoroscopy. (*C, D*) Alignment guide is then removed, and the appropriate resection guide is applied. (*E, F*) The tibial cuts are performed, and the bone removed.

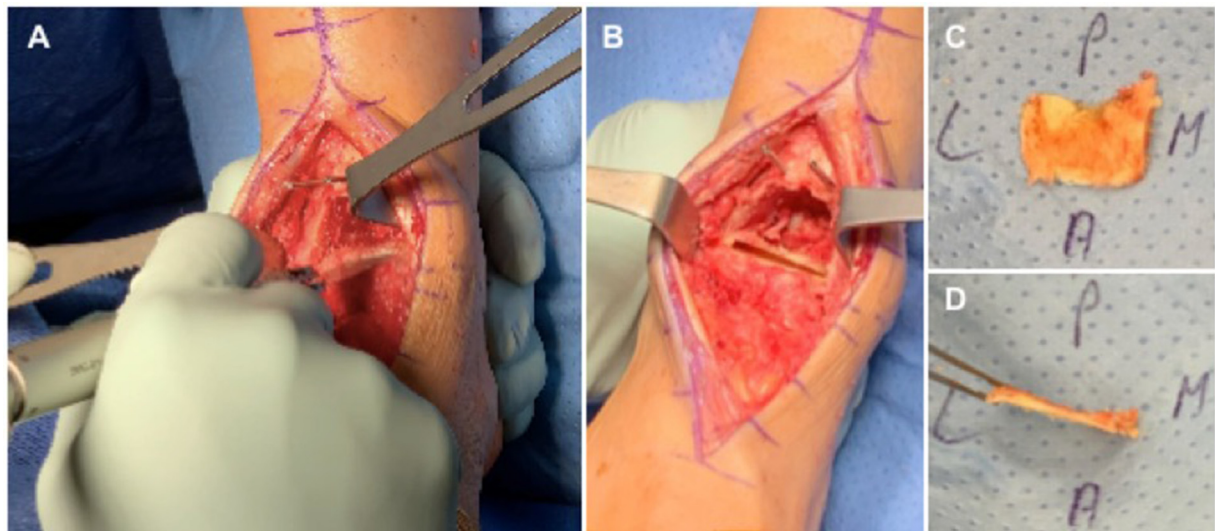

Fig. 3. An initial talar bone cut is performed after soft tissue balancing. (*A, B*) The flat wafer is cut while holding the heel with the foot at 90° to the leg. (*C, D*) The wafer removed should be 3 to 4 mm in thickness on all sides.
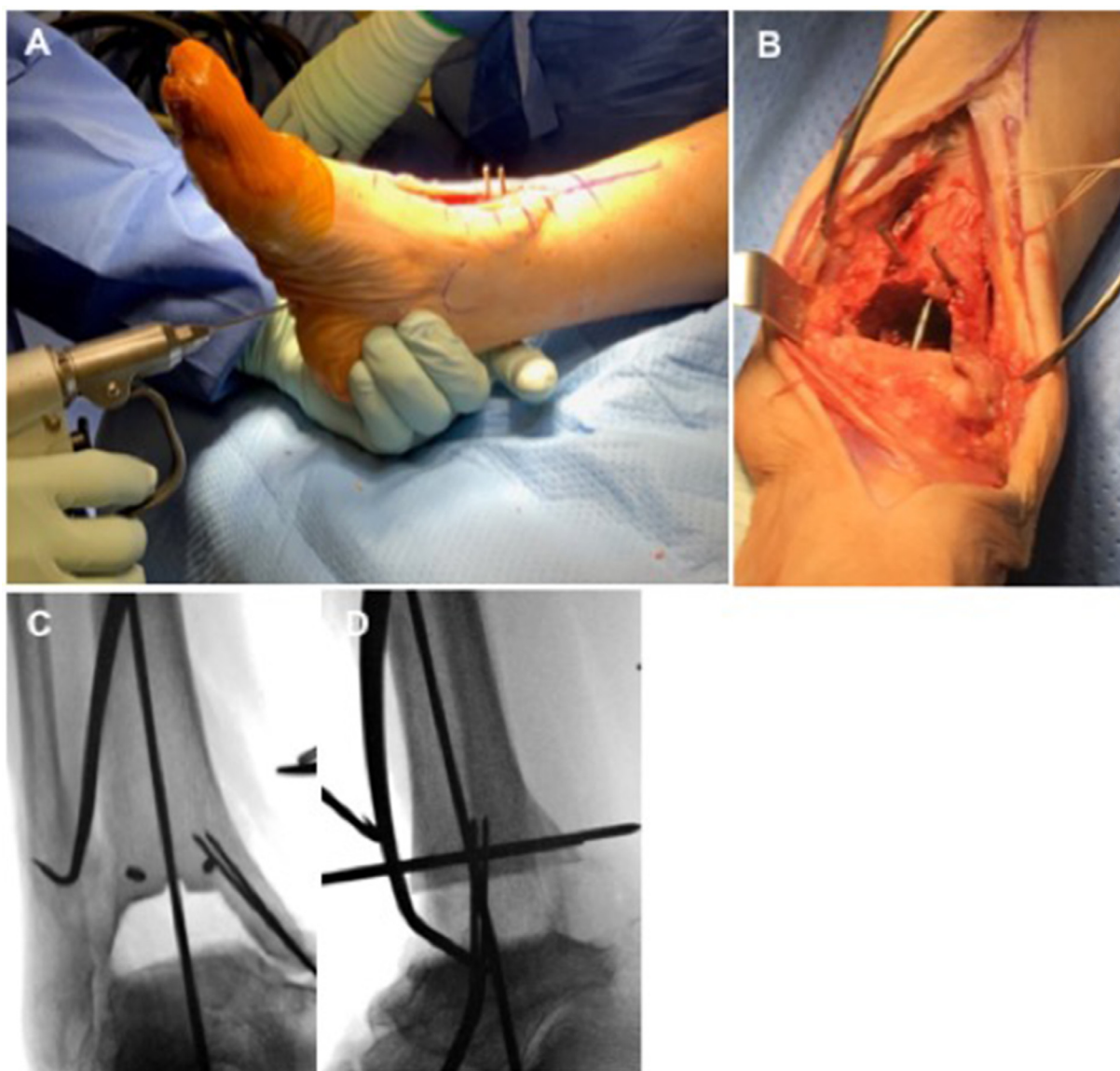
Fig. 4. Without the use of standard intraoperative instrumentation, the guidewire for the tibial stem is placed through the calcaneus, and into the tibia. (*A*) Guidewire insertion is performed in a fashion similar to that for retrograde intramedullary nails. (*B-D*) Guidewire placement is checked both clinically and fluoroscopically for central placement in the coronal and sagittal planes.

Statistical Analysis

Mean $\pm$ standard deviation (SD) was determined for each patient in regard to the radiographic analysis. Inter-rater reliability for radiographic measurements was calculated using the percent agreement method. Unpaired t test was utilized to determine statistical significance (defined as $p \le .05$).

Results

Ten patients underwent this hybrid technique for TAA as described above. The average follow-up time was 15.4 months (range 13-18 months). An open gastrocnemius recession and modified Brostrom lateral ankle ligament stabilization were the most common concomitant procedures. Concomitant procedures performed at the time of TAA are listed in Table 2. The average tourniquet time was 118 minutes, while the average operative time (defined as the initial incision to dressing application) was 168.7 minutes. The average radiation dose as determined by dose area product was 46.8 cGy*cm^2, while the mean fluoroscopic exposure time was 250.5 seconds. Intraoperative characteristics are shown in Table 3.

First weightbearing ankle radiographs were evaluated for postoperative tibial implant alignment. The mean of the 3 evaluator measurements for each patient were calculated and are reported in Table 4. Only 2 values, both in the sagittal plane, fell outside the acceptable deviation for accuracy. The overall mean $\pm$ SD deviation of the tibial implant in the coronal plane was $0.9° \pm 0.5°$, compared to $2.2° \pm 2.7°$ in the sagittal plane. The wider standard deviation in the sagittal plane measurements compared to the coronal plane is graphically demonstrated in Fig. 7. The postoperative tibial implant position corresponded to within 2° of the anatomic axis in 100% of patients in the coronal plane, and 70% of patients in the sagittal plane. The difference between the coronal and sagittal measurements did not reach statistical significance with unpaired t test ($p = .14$). Inter-rater reliability was found to be 83%.
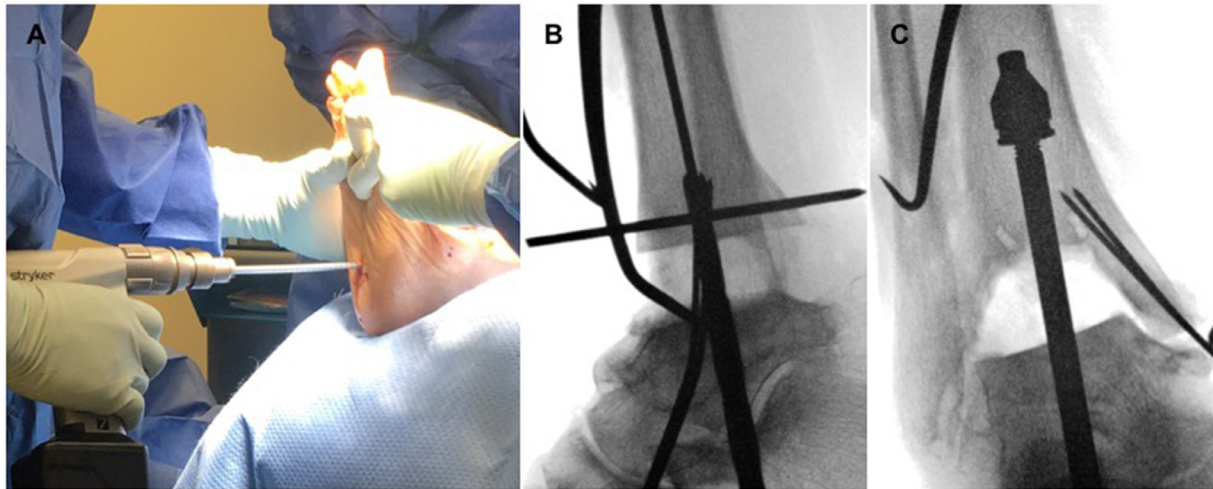
Fig. 5. The tibia is drilled and reamed. (*A, B*) Placement of the drill is checked in coronal and sagittal planes with fluoroscopy. (*C, D*) Reaming is performed by hand and alignment is monitored with fluoroscopy.

Mean VAS preoperatively was 7.4. There was a steady decline in VAS seen over the postoperative course with a mean score of 3.3 at 1 month, 1.8 at 3 months, 1.3 at 6 months, and 0.5 at 1 year postoperatively (Fig. 8). Average time to full weightbearing in a regular shoe was 6.4 weeks (range 3-15 weeks). Complications included one stable intraoperative medial malleolar fracture and superficial incision dehiscence in 2 patients that resolved with local wound care for one and split-thickness skin graft for the other. The overall complication rate was 30%. All complications that were encountered were categorized as low-grade according to the Glazebrook classification (20). We did not encounter any medium-grade or high-grade complications, including implant-related complications. Postoperative characteristics for our patient cohort are demonstrated in Table 5.

Discussion

In this study, we present our technique for a hybrid prosthesis, which combines the advantage of the stability of the stemmed intramedullary tibial implant with the stability and minimal bone resection of the chamfer-cut talar component. It is the experience of the senior surgeon that there is less concern for aseptic loosening with stemmed tibial implants. As previously mentioned, outcomes with the INBONE I
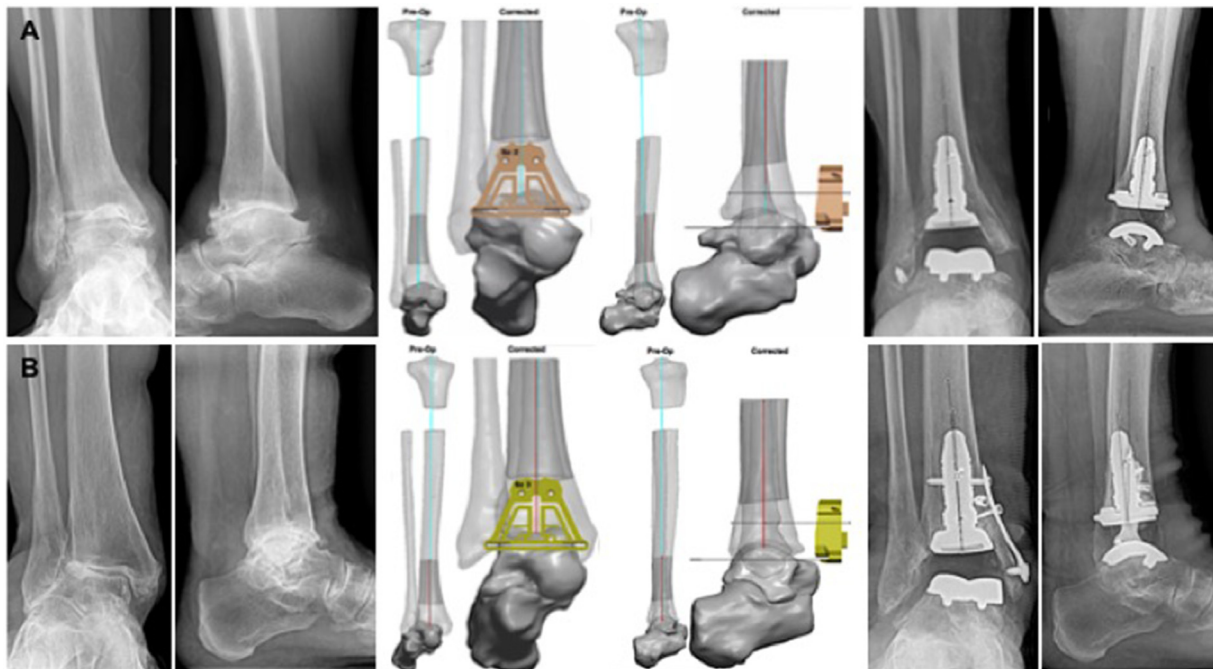

Fig. 6. Representative patient examples including weightbearing preoperative radiographs (left), planned correction via preoperative navigation report (anatomic axis of tibia shown in blue, middle), and postoperative radiographs with measured deviation of the tibial component from the anatomic axis (right). (*A*) 74-year-old female with a 21° varus deformity and history of recurrent ankle sprains. The tibial component was found to be well aligned with the anatomical axis in both the coronal and sagittal planes, as was predicted by preoperative navigation. (*B*) 84-year-old female with osteoporosis with a 22° valgus deformity. Adequate coronal plane alignment was obtained; however, posterior angulation of the implant in the sagittal plane is noted. Patient also sustained intraoperative medial malleolar fracture that was concurrently treated with ORIF.

Table 2
Concomitant procedures performed during TAA

Procedure	No. (%)
Gastrocnemius recession	10 (100%)
Modified Brostrom procedure	7 (70%)
Deltoid peel	3 (30%)
Deltoid plication	2 (20%)
Hardware removal	2 (20%)
ORIF of medial malleolus	1 (10%)

Abbreviation: ORIF, open reduction internal fixation.

Table 3
Intraoperative characteristics

Characteristic	Mean (Range)
Radiation dose (DAP, cGy*m^2)	46.8 (29.6-85.3)
Fluoroscopy exposure time (sec)	250.5 (172-429)
Tourniquet time (min)	118 (82-149)
Operative time (min)	168.7 (126-234)

Abbreviation: DAP, dose area product.

and II implants have shown high survivorship rates with few tibial stem complications compared to the higher possibility of talar component subsidence (8-10,22). Harston et al reported a survivorship of 90.6% with the INBONE I, and a 2.7% rate of revision due to talar component collapse at an average of 6 years' follow-up (8). Another study by Cody et al found that the most common reason for TAA revision at a minimum of 5 years' follow-up was talar subsidence (22). In their study of 4 implants, all cases of talar subsidence were in patients who had received either the INBONE I or INBONE II. Despite this observation, they found that the INBONE II implant had a survivorship of 98%. Similarly, Hsu and Haddad demonstrated a combined survivorship of 96.6% at 2 years' follow-up for the INBONE I and II implants in a series of 59 patients (10). Approximately 25% of patients developed mild or moderate talar subsidence, with 33% requiring operative revision. No complications associated with tibial component failure were reported.

There are obvious advantages of a chamfer-cut talar implant over a flat-cut talus. Studies have demonstrated low rates of talar component subsidence with the INFINITY implant. Saito et al reported a single case of talar component subsidence in their case series of 64 patients (12). The low rate of talar implant failure with the INFINITY implant is theoretically due to its mechanically stabilizing chamfer cut, as well as limited resection of the talar dome. It is in an attempt to harness the advantages of both of these implants that we embark on the initial discussion of combining a stemmed intramedullary tibial component with a chamfer-cut talar component.

The technique that we report has several nuances, including the freehand removal of a minimal wafer of bone from the talus. While we

Table 4
Mean deviation of tibial component from anatomical axis

Patient	Coronal (°)	Sagittal (°)
1	1.0	0.0
2	1.3	1.3
3	0.7	**6.0**
4	1.0	4.0
5	0.0	**8.0**
6	1.0	0.7
7	1.0	1.3
8	0.3	1.0
9	1.7	0.0
10	1.3	0.0

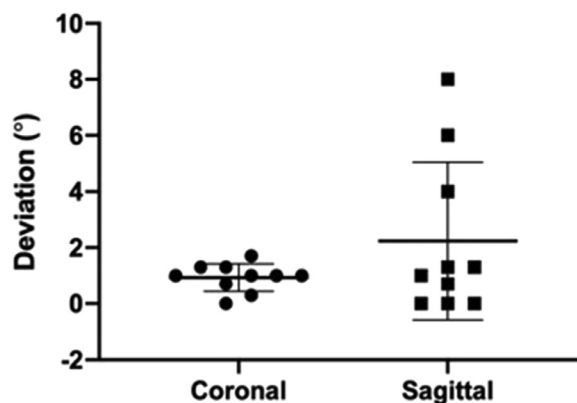**Fig. 7.** Deviation of tibial component from anatomical axis.

Table 5
Postoperative characteristics

Characteristic	Value*
Time to weightbearing (weeks)	6.4 (3-15)
Complications	3 (30%)
Superficial wound dehiscence	2 (20%)
Intraoperative medial malleolar fracture	1 (10%)

* Values in No. (%) or mean (range).

believe that this minimal resection may help prevent subsidence of the talar component, it could be argued that this could lead to an overstuffed joint. However, a known feature of the stemmed intramedullary tibial component is greater tibial bone resection, which we believe negates our minimal bone resection from the talus. Further, extreme care must be taken during this resection in order to remove equivalent amounts of bone from the talus in all planes to prevent improper talar component positioning.

Another nuance associated with this technique is streamlining of the standard intraoperative guide instrumentation. Our experience in foot and ankle surgery includes the use of retrograde intramedullary nails for tibiotalocalcaneal arthrodesis. We considered general principles of placing intramedullary nails when developing one of the key steps to this technique, which involves placing a guidewire through the calcaneus and into the tibia without the use of the traditional INBONE C-bracket and leg holder. We believe that this simplification of the intraoperative instrumentation could have several potential benefits including decreased operative time and radiation exposure from a conventional C-arm.

Fluoroscopy is an important tool in all TAA surgery; however, it is especially important with use of the INBONE total ankle system to ensure colinearity of the intramedullary tibial component in both sagittal and coronal planes during implant placement. As was previously discussed, accurate placement of total ankle components is crucial to overall implant longevity (15-17). However, this may potentially lead to longer radiation exposure time. A study by Angthong et al, demonstrated that patients who underwent TAA with the INBONE system were exposed to 50% more radiation than other implants, which was attributed to the intramedullary tibial component (23).

The benefit of our technique is that it allows use of a mini-C-arm. Studies have shown that use of mini-C-arm results in reduced radiation exposure compared to conventional C-arm (24,25). One study by Dawe et al compared conventional versus mini-C-arm in various foot and ankle surgeries (26). They found that while fluoroscopy screening time was slightly increased in the mini-C-arm group, there was a statistically significant decrease in radiation exposure with mini-C-arm over
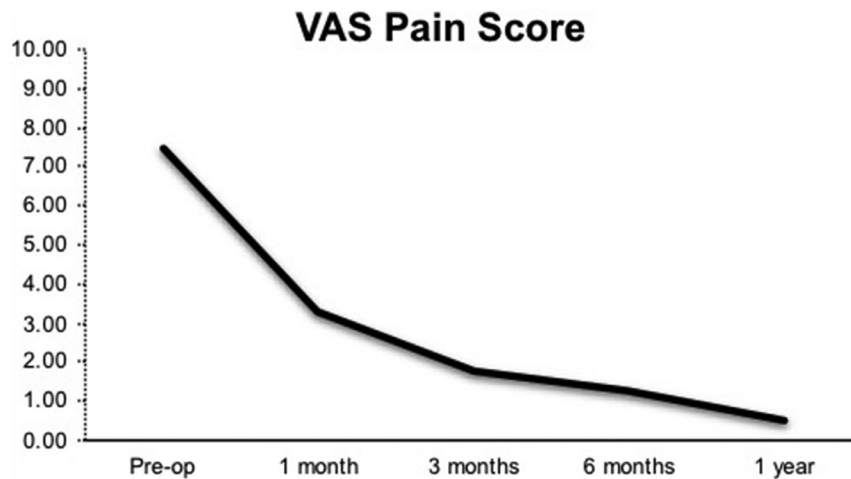
VAS Pain Score

Fig. 8. Mean visual analog pain scale (VAS) preoperatively (pre-op), and at 1 month, 3 months, 6 months, and 1 year postoperatively after our hybrid TAA technique (N = 10).

conventional C-arm. Therefore, while the fluoroscopy time for this technique is potentially higher than the standard technique, we believe that the overall radiation exposure is reduced with the utilization of mini-C-arm.

Another important consideration with this hybrid technique is the tourniquet and operative times. We demonstrated that our average tourniquet time was 118 minutes, and our mean operative time was approximately 169 minutes. Other studies have reported tourniquet times for various TAA implants ranging from 131 to 148 minutes (22,27). Procedure times for the INBONE system, as well as other TAA implants, were reported in an article by Coetzee et al (27). They found that the INBONE prosthesis had the longest operative times (209 minutes) compared to the Salto Talaris (171 minutes) and STAR (182 minutes) implants. They even attributed the additional time for the INBONE system to setting up and positioning the leg holder intraoperatively. As this instrumentation was eliminated in our adaptation of the INBONE technique, it may not be surprising that we had lower tourniquet and operative times in this study compared to prior reports in the literature.

In this preliminary report, we demonstrated that this novel technique could be performed with potentially less radiation exposure and reduced tourniquet and operative times. Our outcomes also support that this hybrid prosthesis is well-tolerated and safe. We saw dramatic decreases in VAS scores postoperatively, similar to those seen with standard implants (8-10). We had minimal complications in the perioperative period, and none of these were related to the implant itself. While our average follow-up was relatively short at 15.4 months, we have yet to have any failures or need for revision.

Our radiographic analysis demonstrated that the intramedullary tibial stem was, on average, placed within approximately 1° in the coronal plane and 2° in the sagittal plane of the preoperative plan determined by preoperative navigation. This was within the previously defined parameters for accuracy of implant placement (15,18,19). We found greater variability in the placement of the tibial stem in the sagittal plane, which we presume may be a result of our guidewire placement technique and/or tibial bone resection. Further study is needed to further understand this observation.

We chose to use the first weightbearing ankle radiographs for our radiographic analysis. Previous studies have reported these radiographs are an accurate representation of implant position as placed in the operating room (18,28). We also chose to only analyze tibial component placement, since the deviation from the anatomic axis represented a deviation from the preoperative navigation, which was only utilized for the stemmed intramedullary tibial component. Further, the

intraoperative instrumentation (i.e., leg holder and C-bracket) that was eliminated with this technique are used for placement of the tibial component.

This study had many limitations, including the retrospective nature and small study population. Also, the nuances for placement of this hybrid prosthesis using our method, such as the freehand guidewire placement for the stemmed intramedullary tibial component, may be technically difficult for inexperienced surgeons, or those not familiar with retrograde intramedullary nails. In this study, we report an alternative technique for placing a stemmed intramedullary tibial component, which is one method of combining this implant with a chamfer-cut talar component. While we hope that this report adds an alternative technique to the expanding literature on TAA, it is not intended to promote a technique in place of the standard surgical technique for either of these implant systems.

In conclusion, we demonstrate that it is possible to combine a stemmed intramedullary tibial component with a chamfer-cut talar component, which we believe provides greater osseous stability and may reduce the risk of talar component subsidence. To our knowledge, we are the first to report on this hybrid technique for TAA. Additionally, we show significant pain reduction, and minimal complications with at least 1-year follow-up. Further, we have shown that this hybrid approach is reproducible and accurate in obtaining a well-aligned tibial implant radiographically without use of the traditional intraoperative instrumentation for insertion of the tibial stem. Further studies with a larger patient population are in progress to evaluate long-term outcomes with this technique; however, our preliminary results are encouraging.

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