Managing Intraoperative Fractures During Total Ankle Replacement

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KEYWORDS

• Total ankle complications • Periprosthetic fractures • Total ankle replacement

KEY POINTS

Intra-operative fractures are common and constant vigilance is needed to avoid fracture occurrence. A few specific technical tips are noted later in discussion.

- Avoiding over resection of the medial malleolus when choosing medial-lateral resection of the tibia
- Use of saw capture guides for the tibial and talar cuts, with special attention to medial-lateral resection when cutting the talus.
- Using caution and slow impaction if using a corner chisel on the tibial cut
- If a trial or definitive implant seems too wide medially or laterally, either downsize to a smaller implant, or use a reciprocating saw to gently widen the medial-lateral resection
- Impact the tibial component squarely in the coronal plane, without leaning medially or laterally

INTRODUCTION

Intraoperative complications during total ankle replacement (TAR) can be devastating.[1–4] As surgeons' experience with total ankles grow and surgical techniques are refined, intraoperative complications, such as fractures, can still occur. Surgeons must be able to recognize a problem, identify the options to remediate, and then execute a solution readily. Unfortunately, given the heterogeneity of TAR outcome studies, it is difficult to garner the true incidence of complications in the peri-operative period following ankle replacements. The purpose of this review is to focus on perioperative fractures during TAR. Fractures can occur intraoperatively and postoperatively as stress fractures or post-operative trauma. Periprosthetic fractures have been reported for every type of ankle implant design.[5]

In this article we seek to discuss complications and total ankle replacement as a whole, describe the types of intraoperative and postoperative fractures with total ankle, and provide an algorithm for the management of perioperative periprosthetic fractures.

Etiology of Intraoperative Fractures

Most intra-operative fractures are iatrogenic. They are often associated with inadequate exposure by the jig itself or size of the resection guide. Inadvertent use of the saw blade can cause fibula or medial malleolar fractures.

Medial malleolar fractures occur frequently due to the small bone bridge between the medial cortex and implant and can occur during the following surgical steps.

- Not checking medial-lateral positioning of cut guide after adjusting for sagittal or coronal balance
- Inadvertent saw blade cut while cutting talus through the jig
- Using a corner chisel to finish tibial cuts

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- Removing corner chisel by levering off the medial malleolus
- Trialing implants that may be too tight to fit
- Impaction of tibial implant eccentrically

Lateral malleolar fractures occur much less commonly than medial malleolar fractures, with an intra-operative lateral malleolar fracture rate of roughly 14% of the rate of medial malleolar fractures.[6] However, they still occur at very specific times during an ankle replacement. Some 4th generation total ankle implants have a tibial component design that allows for the incinsura ([Exactech's Vantage [Gainesville, FL]; Cadence [Smith + Nephew, Watford, England]; Kinos [restor3d, Durham, NC]]) to facilitate a broader, tricortical footprint for the tibial component to be placed. During tibial bone preparation, the fibula is at tremendous risk when a surgeon needs to remove the entire lateral aspect of the tibia given then the fibula is recessed in its notch. The posterolateral border of the tibia cannot be sawed from the anterior aspect, but from the anteromedial aspect of the jig. (FIGURE)

Anterior or posterior tibial fractures can occur in patients during the impaction of the tibial baseplate.

Intra-operative talus fractures are an exceedingly rare complication of total ankle arthroplasty and can be of the neck or body. Talar neck fractures can occur in certain ankle systems in which the talar neck is removed for an anterior flange of a talar component. Another instance of increasing the risk of injuring the talus is in short necked talus and a chamfer is used when a flat top talus should have been, there by over-resecting the talar neck, increasing the talus fracture risk. The talar body is at risk for fracture during implantation.

Post-traumatic periprosthetic fractures of the ankle can result from forces that would have caused an injury to the region regardless of the presence of an implant, but also due to the inherent nature of the implantation process in general. Every total ankle system relies on pinning cutting guides and jigs into the tibia and talus. Therein, these small bicortical holes represent a significant iatrogenic stress riser that could weaken bone in mechanical loading. These holes raise the local stress in the region of the defect while the rest of the bone is relatively unperturbed by normal forces acting upon it. Up to 90% of periprosthetic fractures occur through a previously-made drill hole.[7] In a cadaveric study of 3.5 mm drill holes on the fibula,[8] the drilled fibulas failed at 59.6% of the mean load that was needed to fracture intact fibulas. A hole sized less then than 20% of the diameter of the bone can weaken the bone by 40% in bending and 12% in torsion.[9]

Post-operative pain following a TAR is a common etiology of patient dissatisfaction. Patients recovering from their arthroplasty have worsening pain and swelling at the 90 day timepoint postoperatively but then show gradual improvements in their function, pain, and range of motion for a year.[10] Patients who complain of persistent medial pain at the ankle have to be worked up and possibly treated for a stress fracture. At our institution, we check and correct any metabolic deficiencies, followed by imaging with a CT scan (FIGURE). We have tried Metal Artifact Reduction Sequences (MARS)-protocoled MRIs, but it did not give us the sensitivity needed to guide treatment. We have found some help in obtaining bone SPECT/CT scans to identify other potential sources of pain.[11]

In a study of 74 TAR performed by a single surgeon,[12] six patients who had persistent medial ankle pain at a mean of 12 months following index TAR underwent percutaneous placement of two medial malleolus screws drilled from the malleolar tip to proximal to the implant. VAS scores significantly improved in all patients. Interestingly, the average minimum width of the medial malleolus at the level of the tibial component was 2 mm thinner in those who had medial pain than a control group (10.2 vs 12.2 mm, $P < .05$) and there were no radiographic signs of medial malleolar stress injury. Doets and colleagues reported on mobile-bearing devices in 93 patients with inflammatory arthritis.[13]Four patients developed atraumatic fractures of the distal tibia at the level of the tip of the stem of the tibia component. It was noted intra-operatively that these patients had severe osteopenia. All were treated successfully with cast immobilization.

A prospective collected database of 194 ankles was screened for all periprosthetic fractures.[14] Seven intraoperative and 9 postoperative periprosthetic fractures were identified (3.5% and 4.5%, respectively). Seven patients (3.5% of total or 43.8% of all fractures) underwent TAR removal or revision. Lower tibial and talar Hounsfield units (HU, a measure of bone radio density derived from a computer tomography scan), lower weight, and lower BMI were associated with periprosthetic fractures. Once the researchers controlled for age, sex, and weight, only a decreased tibial HU was significantly associated with periprosthetic fracture.

All intraoperative fractures occurred in patients with tibial HU less than 200.

Incidence

In an evidence-based classification of complications in total ankle replacement,[15] intraoperative fractures and wound healing problems are considered low-grade complications in TAR. Technical error, subsidence of the implant and postoperative periprosthetic fracture are considered medium grade complications. The high-grade complications included deep infection, aseptic loosening, and implant failure. The level of danger a particular complication achieved was based on if it caused surgical failure greater than 50%, less than 50%, or rarely. The 20 studies that met inclusion criteria, intraoperative fractures caused 0% of implant failure and an incidence of 8.1%. This was the third most common complication surrounding an ankle replacement surgery. Fractures after a total ankle replacement occurred in 5% of individuals which led to 16.7% of the rate of failure the given complication.

There are two recent systematic literature reviews and meta-analyses regarding complications following total ankle arthroplasty.[16,17] In a systematic review which reported on 16,000, 964 ankles average follow-up of 48 months,[16] the highest complication was an intraoperative fracture (5.6%), followed by impingement. In their meta-analysis, they demonstrated a fracture rate of 4.9% of the medial malleolus and 1.7% of the lateral malleolus. Of all the fractures listed, 77% of them were fixed during the index surgery. Postoperative fractures occurred roughly 4.0% of the time. In another systematic review of 4412 ankles,[17] intraoperative fractures occurred roughly 2.8% of the time, while postoperative fractures occurred in 1.3% of all total ankle replacements.

In a study of a 505 TARs from a single center over 10 years of a single implant, a total of 21 patients with a periprosthetic fracture were identified.[5] There were 11 intra-operative and ten post-operative fractures. Of the eight stress fractures, five were treated conservatively and the remaining three were treated operatively. Patients who had intraoperative ankle fractures had statistically better patient-reported outcome (PROs) measures than those who had stress or post-traumatic fractures, though their pain scores were the same. All patients achieved union, though 3 (14.3%) had delayed union.

A Treatment Algorithm

We recommend the immediate and primary fixation of intra-operative periprosthetic fractures. This allows normal post-operative osseous integration of the prosthesis and routine early rehabilitation. We believe that this decreases implant loosening or subsidence. Furthermore, the risk of nonunion is minimized.

Avoiding Intra-operative Fractures

Intra-operative fractures are common and constant vigilance is needed to avoid fracture occurrence. A few specific technical tips are noted later in discussion.

- Fluoroscopic verification of medial-lateral positioning of tibial cut guide after adjusting for sagittal or coronal balance
- Avoiding over resection of the medial malleolus when choosing medial-lateral resection of the tibia
- Use of saw capture guides for the tibial and talar cuts, with special attention to medial-lateral resection when cutting the talus.
- Using caution and slow impaction if using a corner chisel on the tibial cut
- When removing the corner chisel, try to either pull the chisel straight out, or if anything lever inferiorly. A back-slap on the corner chisel can be useful to help with this step.
- If a trial or definitive implant seems to wide medially or laterally, either downsize to a smaller implant, or use a reciprocating saw to gently widen the medial-lateral resection
- Impact the tibial component squarely in the coronal plane, without leaning medially or laterally

Treatment of Medial Malleolar Fractures

Medial malleolar fractures are the most commonly encountered intra-operative fracture.[3,5,18] Most commonly, these occur during oscillating saw use while resecting the distal tibia, or less commonly during tibial component impaction. All intra-operative medial malleolus fractures should be stabilized to allow for maximal prosthesis integration, appropriate ligamentous balancing, and to reduce the risk of any future medial malleolar stress injuries.

Of note, in an analysis of bone tension during the fixation of an intraoperative medial malleolus fracture,[19] a finite element study based on CT examinations demonstrated that fracture fixation using a Blount staple leads to lowest bone tension (by half) around the fixation of the medial malleolus versus a screw or staple and screw construct. However, good results have

been reported with the use of cannulated screw fixation, as well as less commonly plate fixation. All approaches are reasonable and typically have high associated rates of union.

Figs. 1–3 are the intra-operative and post-operative radiographs of an intra-operative medial malleolus fracture treated with cannulated screw fixation. Fig. 4 shows a 6 week post-operative X-rays of an uncomplicated total ankle (see Fig. 4), which sustained a medial malleolar fracture at 3 months post-operative, seen on X-ray and CT (Figs. 5 and 6 respectively). This was treated with a medial distal tibial locking plate (Fig. 7) which went on to un-eventful union (Fig. 8 shows a post-operative CT scan)

Treatment of Lateral Malleolar Fractures

Peri-prosthetic fibular fractures are likely the second most common intra-operative peri-prosthetic fracture behind medial malleolar fractures.[3,5,18] Intra-operative fibular fractures are thought to most commonly occur while using an oscillating saw to create either the initial tibial or talar cut. Less commonly, fibular fractures can occur from during the insertion of the tibial component if the medial to lateral distance of the tibial component is wider than the resected bone. The vast majority of inter-operative fibular fractures are unstable and warrant stabilization, allowing for maximal prosthesis inter-osseous integration. Most commonly this is performed through open reduction and internal fixation via a direct lateral approach and fixated with a plate. The majority of these fractures tend to

Fig. 2. Weightbearing mortise view of a medial malleolar fracture fixed with cannulated screws.

Fig. 1. Intra-operative fluoroscopy of a medial malleolar fracture fixed with cannulated screws.

Fig. 3. Weightbearing lateral view of a medial malleolar fracture fixed with cannulated screws.

Fig. 4. Post-operative weightbearing ankle radiograph after total ankle replacement.

be transverse in nature, and a locking plate can sometimes be useful, as the fibula fractures can sometimes be fairly distal on the fibula. Occasionally, in more proximal fractures, a fibular nail can also be used as an alternative to a plate.

Figs. 9 and 10 show a typical case of an intra-operative distal fibular fracture treated with open reduction and internal fixation with a distal fibular locking plate. This went on to un-eventful union as shown in Figs. 11 and 12.

Treatment of Talus Fractures

Inter-operative talus fractures are less common than medial malleolus and fibular fractures and can be more challenging to manage.[5,16,18,20] Intra-operatively, these fractures most commonly occur during the impaction of the talar component. The surgeon should ensure that either the implant is stable prior to proceeding with fracture fixation, or if the implant has not yet been fully impacted, then the fracture should be fixated first then the implant fully seated. In some instances, revision of the talar component may be necessary to ensure talar stability and correct talar position.

One of the more common patterns of talar fracture is a talar neck fracture, which is often transverse and occurs just distal to the anterior flange of the talar component during impaction. Talar fracture are almost always unstable and require stabilization. This is most commonly performed by extending the anterior approach to the tala-navicular joint and opening the talar navicular joint. This allows for the placement of anterior to posterior screws from the talar head into the talar body, stabilizing a talar neck fracture. A sinus tarsi incision can also be created if either better visualization of the reduction is needed or if the placement of a lateral plate, though this is usually not required.

Treatment of Post-op Fractures

Periprosthetic fractures can be challenging to treat for both the surgeon and patient. Lazarides

Fig. 5. Weightbearing mortise view of a post-operative medial malleolus fracture.

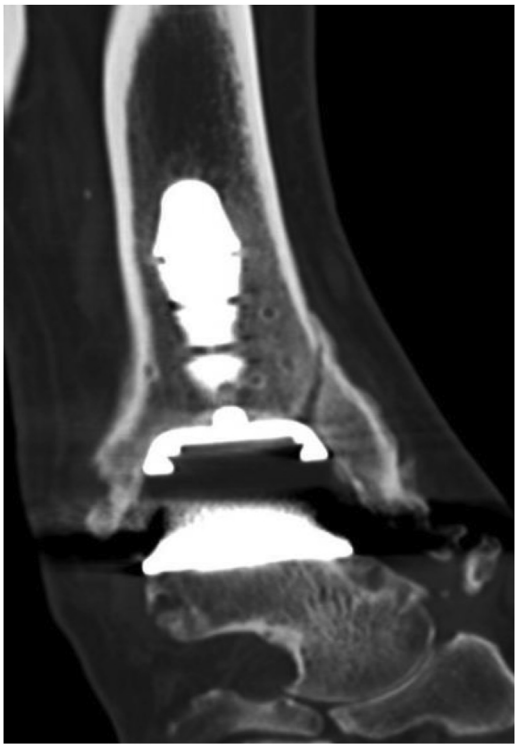

Fig. 6. Coronal computer tomography view of a post-operative medial malleolar fracture.

Fig. 8. Coronal computer tomography view of post-operative medial malleolar fracture treated with a medial locking plate which went on to union.

Fig. 7. Weightbearing mortise view of a post-operative medial malleolus fracture treated with a medial locking plate.

Fig. 9. Intra-operative fluoroscopic mortise view of a distal fibular fracture fixed with a locking plate.

Fig. 10. Intra-operative fluoroscopic lateral view of a distal fibular fracture fixed with a locking plate.

Fig. 12. Weightbearing lateral view of a distal fibular fracture fixed with a locking plate.

Fig. 11. Weightbearing mortise view of a distal fibular fracture fixed with a locking plate.

Fig. 13. Intra-operative fluoroscopic lateral view of a talar neck fracture treated with solid screw fixation.

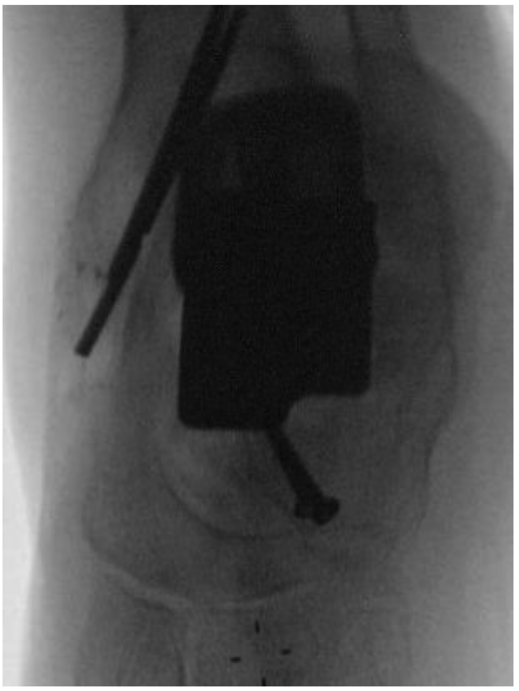

Fig. 14. Intra-operative anterior to posterior foot view of a talar neck fracture treated with solid screw fixation.

Fig. 15. Weightbearing lateral view of an a talar neck fracture treated with solid screw fixation which went on to union.

and colleagues reviewed 32 post-operative fractures around total ankle arthroplasties, and only found one which was successfully treated conservatively.[20] Given these findings, surgical stabilization is recommended for all periprosthetic, complete fractures.

Of note, medial malleolus fractures have been noted to occur in the early post-operative period in association with varus position of the tibial implant.[5] This is varus mal-position of the tibial component is thought to cause an insufficiency fracture of the medial malleolus.[5] When there is substantial varus mal-position of the tibial component in the coronal plane, this is likely best treated with either a corrective supramalleolar osteotomy or tibial component revision. Other medial malleolar fractures in the early post-operative period are likely best treated with definitive stabilization. Figs. 13 and 14 show an intra-operative talar neck fracture which was treated with stabilization with two anterior to posterior talar screws. This went onto uneventful union as shown in Fig. 15.

CLINICS CARE POINTS

- Most intra-operative fractures are iatrogenic. They are often associated with inadequate exposure by the jig itself or size of the resection guide.
- Inadvertent use of the saw blade can cause fibula or medial malleolar fractures.
- When planning the width of the implant, please consider the width of the medial malleolus as one does not want to leave less than 11mm.
- Lateral malleolar fractures occur much less frequently than medial malleolar fractures; they still occur at very specific times during an ankle replacement.
- Patients who complain of persistent medial pain at the ankle have to be worked up and possibly treated for a stress fracture.

DISCLOSURE

The authors have nothing to disclose.

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