Technical Note
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A Novel Approach to Total Ankle Arthroplasty with Simultaneous Structural Tibial Cut Autograft for Anterior Tibial Bone Defects

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Severe bone defects pose a clinical challenge in total ankle arthroplasty (TAA) and are frequently considered contraindicated. We introduce an innovative approach that utilizes a structural tibial cut autograft to address anterior distal tibia bone defects during TAA. This technique is a viable alternative to employing revision TAA systems or resorting to excessively high tibial cuts. Furthermore, it facilitates achieving favorable sagittal alignment and ensures adequate fixation strength of the tibial component.
Keywords: *Ankle, Arthritis, Bone defect, Arthroplasty, Bone graft*

Total ankle arthroplasty (TAA) has emerged as a popular intervention for end-stage ankle arthritis. Precise alignment in both the coronal and sagittal planes is crucial for the success of TAA.[1-3] Residual sagittal malalignment after TAA can result in a reduced range of motion and edge loading, leading to unfavorable clinical outcomes and early failure.[3]

Addressing sagittal deformities associated with severe anterior distal tibia bone defects during TAA poses technical challenges. Surgical interventions involving revision TAA are considered in such cases. However, achieving normal sagittal alignment often requires a high tibial cut, potentially compromising bone stock for tibial component fixation. Notably, a prior study reported suboptimal outcomes and a higher incidence of additional revision surgeries following the implantation of revision TAA systems compared to primary TAA procedures.[4]

In this context, our study introduces a surgical approach to manage severe bone defects in the anterior distal tibia during TAA. This approach involves the implantation of a primary TAA system and simultaneous structural bone grafting using a resected autogenous posterior tibial bone segment. The goal is to achieve both satisfactory sagittal alignment and ample bone stock in the distal tibia, thereby facilitating the successful implantation of the primary TAA prosthesis.

TECHNIQUE

The present study was approved by the Institutional Review Board of Severance Hospital (IRB No. 4-2023-1437), which waived the requirement for informed consent given the retrospective nature of the study.

Indications

The primary indication for employing this technique is end-stage ankle arthritis characterized by an anterior tibial bone defect, with more than half of the posterior articular bone stock remaining intact. However, it may not be suitable for patients presenting with a bone defect extending to the posterior joint line or displaying diffuse cystic

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changes in the posterior distal tibia, along with general contraindications for TAA.

Surgical Technique

Preoperative planning involves assessing sagittal malalignment and the extent of the anterior tibial bone defect. The preoperative anterior distal tibial angle is measured on a standing lateral radiograph and defined as the angle between the anatomic axis of the tibia and a line connecting the distal points on the anterior and posterior tibial articular surface. Computed tomography is performed for precise evaluation of deformity and bone stock.

Under general or spinal anesthesia, the patient assumes a supine position with proper padding under the ipsilateral hip. A pneumatic tourniquet is applied to the ipsilateral thigh and inflated. The anterior approach exposes the ankle joint through the interval between the tibialis anterior and extensor hallucis longus tendons, with careful attention to the neurovascular bundle. Capsulotomy, osteophyte removal, inflamed synovial tissue excision, and gutter debridement follow. The sclerotic bony surface of the distal tibia is trimmed, and the resection height is checked under fluoroscopic guidance, approximately at the middle of the defect site on the sagittal plane.

A transverse cut is made, followed by a medial vertical cut using a sagittal saw. A small curved osteotome detaches the resected bone of the posterior lip of the distal tibia, with care not to split the bone. Contouring and preparation of the anterior bone defect site and the resected autogenous tibial bone segment are conducted using a motorized burr or small sagittal saw. One or 2 contoured bone segments are fitted onto the anterior bone defect site, turned over, and impacted with a gentle maneuver. Two 0.9-mm or 1.2-mm Kirschner wires are used to fix the grafted bone (Fig. 1).

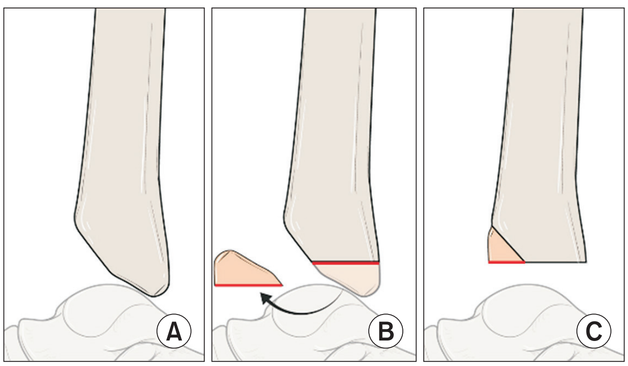

Fig. 1. (A) Schematic drawing of an arthritic ankle with anterior tibial bone defect. (B) Filling the bone defect of the anterior distal tibia with rearrangement of the tibial autograft. (C) The auto-tibial bone was grafted on the defect site.

The extramedullary jig for tibial cutting is placed using a standardized method. The tibial cutting block is positioned just proximal to the distal margin of the grafted bone to minimize resected bone. After confirming sagittal alignment under fluoroscopic guidance and achieving a neutral to slight anterior inclination with the saw blade inserted into the tibial cutting block, tibial resection is performed. Subsequently, talar cutting and primary TAA prosthesis implantation follow the manufacturer's system-specific instructions. The surgical wound is closed with the placement of a suction drain, and a compressive dressing is applied.

Postoperative Care

Postoperatively, a below-knee cast is worn for 6 weeks in a neutral position, allowing partial weight-bearing. After

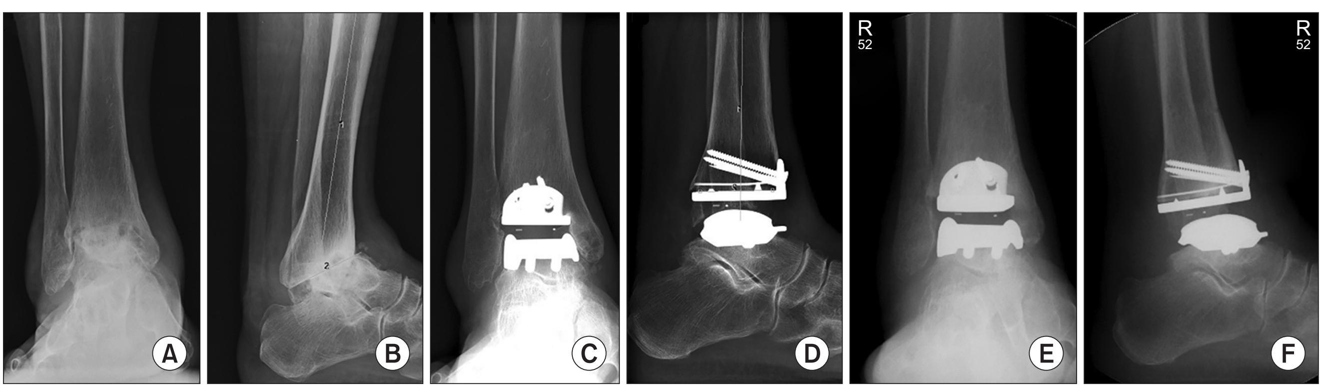

Fig. 2. (A, B) Preoperative weight-bearing anteroposterior and lateral radiographs illustrating ankle arthritis with an anterior distal tibial angle of 46.0° and an 18.2-mm bone defect. (C, D) Postoperative 6-week standing anteroposterior and lateral radiographs depicting union of the grafted structural bone. (E, F) Postoperative 94-month standing anteroposterior and lateral radiographs showing corrected sagittal deformity with an anterior distal tibial angle of 88.6°.

Table 1. Patient Characteristics and Clinical Outcomes

Patient	Sex	Age (yr)	Follow-up (mo)	Etiology	Height of bone defect (mm)	Thickness of used inlay (mm)	VAS score		AOFAS score		AOS pain		AOS disability		ADTA (°)		Ankle motion (°)	
							Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	M	58	46	Posttraumatic osteoarthritis after Pilon fracture	19.3	7	9	0	14	93	63	4	71	16	54.1	84.2	15	35
2	F	56	94	Rheumatoid arthritis	18.2	7	10	2	33	82	65	27	59	38	46.0	88.6	5	40
3	F	50	151	Posttraumatic osteoarthritis after Pilon fracture	13.3	5	8	3	35	84	63	27	73	41	47.8	84.5	20	30
4	F	60	105	Posttraumatic osteoarthritis after recurrent instability	17.8	7	9	1	48	90	74	2	65	11	51.9	84.4	25	40

VAS: visual analog scale, AOFAS: American Orthopaedic Foot and Ankle Society, AOS: Ankle Osteoarthritis Scale, ADTA: anterior distal tibial angle, Pre: preoperative, Post: postoperative.

removing the cast at 6 weeks, a walking boot with a strap is used for additional 4 weeks; the wearing period is determined by the patient's symptoms and radiographic findings. Patients are instructed to perform range-of-motion and muscle-strengthening exercises, progressively advancing weight-bearing levels and activities following cast removal.

Outcome and Follow-up

Four patients underwent this procedure with the HINTEGRA (Newdeal/Integra) primary TAA prosthesis for end-stage ankle arthritis with an anterior bone defect of the distal tibia, with a mean follow-up period of 99.0 months (range, 46–151 months). The mean anterior distal tibial angle was corrected from 51.2° (range, 47.9°–54.1°) preoperatively to 86.0° (range, 84.2°–88.6°) postoperatively. Clinical scores and ankle range of motion demonstrated improvement (Fig. 2, Table 1). One patient underwent minor revision surgery (curettage of an osteolytic cyst, autogenous iliac cancellous bone graft, and polyethylene inlay exchange) at 125 months after TAA for periprosthetic osteolysis of the talus. No other complications, such as infection, bone graft site nonunion, aseptic loosening, or component subsidence, were observed in all cases.

DISCUSSION

The primary cause of ankle arthritis is posttraumatic osteoarthritis, commonly observed following tibial plafond fractures, leading to increased anterior tibial opening and substantial bone defects. Such deformities can also result from concentrated loading stress on the front of the ankle due to stretched anterior talofibular ligaments in cases of osteoarthritis with severe instability. Additionally, inflammatory arthritis, such as rheumatoid arthritis, can contribute to severe bony erosion of the anterior distal tibia.

Managing severe sagittal deformities with accompanying bone defects during TAA presents challenges, and large bone defects are considered a relative contraindication for TAA. In ankles with malalignment, correcting deformities in all planes is crucial for optimal long-term TAA outcomes.[2] Cho et al.[2] highlighted the anteroposterior slope of the tibial component as a critical factor in sagittal alignment restoration during TAA. Inadequate correction of the distal tibial anterior inclination may lead to malpositioning of the tibial component, termed "forward facing," and anterior translation of the talar component during the initial surgery.[5] In terms of functional outcomes, sagittal malalignment restricts dorsiflexion due to implant impingement or excessive soft-tissue tension.[2]

Moreover, this malalignment in TAA induces edge loading on the polyethylene bearing by shifting the center of pressure to its posterior edge, resulting in prosthesis failure.[3]

The modification of the surgical technique using the revision TAA system described by Hintermann et al.[6] may be considered for bone defect of the anterior distal tibia. They suggested using revision tibial components with thicker baseplates than primary components for the > 10 mm of osseous defect.[6] However, concerns persist regarding inferior outcomes and prosthesis survival with revision components, including the risk of intraoperative medial malleolar fractures and poor implant stability due to compromised bone strength.[4,7] A 2-staged revision technique for managing failed TAA with bone defect described by Alsayel et al.[8] is also applicable. However, it requires autogenous bone harvesting from a distant site and staged surgery. Ankle arthrodesis, another option, may lead to nonunion, adjacent joint arthritis, and motion loss and necessitates substantial autograft or allograft bone for structural support.

Our novel technique offers distinct advantages over the aforementioned surgical alternatives. First, it allows for a lower tibial cut height, preserving normal joint kinematics and minimizing the risk of intraoperative or postoperative medial malleolus fractures. Additionally, preserving bone stock provides more future revision options. Second, it ensures proper implant fixation strength. Kofoed[7] highlighted that only the distal 1.5 cm of the distal tibia possesses sufficient strength for implant fixation, emphasizing the need to preserve the anterior cortex to prevent possible loosening. Utilizing the autograft from the tibial distal cut facilitates positioning the tibial component on the solid subchondral bone with an intact anterior cortex. Third, there is no need to harvest autologous bone from a distant site, eliminating the risk of donor site morbidity.

There are limitations to our technique. First, it may not be suitable for ankles with poor bone quality in the posterior lip of the distal tibia. Large cyst formation or severe focal osteoporotic changes could increase the risk of tibial component subsidence after TAA, necessitating a thorough evaluation of bone quality and quantity through regional computed tomography scans. Second, this technique is unsuitable for certain TAA systems with a tibial component design featuring a long keel from anterior to posterior, as the preparation of the tibial keel may lead to the splitting of grafted autogenous bone. Our technique is most appropriate for tibial implants with short and oblique pegs or an anterior shield.

In conclusion, our technique achieves improved sagittal alignment and preserves crucial bone stock during TAA. It stands as a valuable option for addressing complex ankle pathologies with significant anterior distal tibia bone defects. This approach marks a transformative advancement in TAA, offering a promising solution for advanced cases.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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