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Case Report

Valenti Arthroplasty with a Dermal Graft Spacer in Stage III–IV Freiberg's Disease: A Case Report

Mohammad Junayed Khan [1,*], Tashfia Noor [2,*], Ayesha Naveed [3], Hadiya B. Sadiq [4], Hajar Ouassari [5] and Danny Basel Ghannoum [6]

1 The Chautauqua Center, Dunkirk, NY 14048, USA
2 Weill Cornell New York Presbyterian Brooklyn Methodist Hospital, Brooklyn, NY 11215, USA
3 University Health Lakewood Medical Center, Kansas City, MO 64108, USA; ayesha.naveed@uhkc.org
4 School of Podiatric Medicine, Samuel Merritt University, Oakland, CA 94612, USA; hadiya.sadiq@samuelmerritt.edu
5 School of Podiatric Medicine, Barry University, Miami, FL 33161, USA
6 Professional Education and Research Institute, Roanoke, VA 24016, USA
* Correspondence: mjk.dpm@gmail.com (M.J.K.); tashfiatnoor@gmail.com (T.N.)

Abstract

Freiberg's disease is a rare condition involving osteochondrosis and collapse of the metatarsal head, often leading to chronic pain and impaired mobility. Traditional surgical treatments such as osteotomies, autografts, and joint replacements can relieve symptoms but may compromise joint mechanics or cause donor-site complications. In this case, a 23-year-old woman with Smillie stage 3–4 disease underwent a Valenti-type resectional arthroplasty combined with a folded, decellularized dermal graft spacer to preserve joint function. The procedure resulted in rapid recovery, with pain-free motion and restored within weeks. Radiographs showed remodeling of the metatarsal head, and the patient remained fully ambulatory without complications. This technique offers a promising joint-preserving alternative for young, active patients, although further research is needed to confirm its long-term efficacy.

Keywords: Freiberg's disease; surgery

1. Introduction

Freiberg's disease was first described in 1914 by Alfred H. Freiberg, who initially attributed it to acute trauma [1]. The condition is more commonly seen in female patients (female-to-male ratio as high as 5:1), particularly during adolescence or the second decade of life; it is also prevalent in individuals involved in activities such as ballet, gymnastics, or running that place repetitive stress on the forefoot [2]. While the exact cause of Freiberg's disease remains unknown, several factors are thought to contribute. These include repetitive microtrauma leading to vascular compromise, abnormal foot biomechanics such as a long second metatarsal or metatarsus primus elevatus, compromised blood supply to the metatarsal head during rapid growth, and, less commonly, systemic factors such as osteopenia or hormonal influences. Together, these factors may predispose the metatarsal head to subchondral stress, ischemia, and ultimately avascular necrosis.

Smillie's classification categorizes Freiberg's disease into five stages that reflect the progressive pathological changes of the metatarsal head. Stage 1 is characterized by subchondral bone damage of the ischemic epiphysis with the articular cartilage intact [3]. Stage 2 is identified by proximally occurring absorption of cancellous bone beneath the

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osteochondral fragment [3]. Stage 3 is denoted by increased osseous absorption via the development of large projections on either side of the metatarsal head as the central portion of the fragment depresses further [3]. Stage 4 is characterized by continued depression, causing the plantar hinge to break, and the peripheral, bony projections of the fracture to collapse over the central portion [3]. At this point, the cartilage cap has lost its integrity and anatomic restoration is no longer possible. Stage 5 is characterized by severe joint arthrosis and concurrent metatarsal head deformity, with the osteochondral fragment becoming a loose body [3].

Initial conservative care focuses on reducing forefoot stress with activity modification and offloading. Most mild to moderate cases are managed with protected weight-bearing in a stiff-sole shoe, post-op shoe, or CAM boot rather than full non-weight-bearing [4]. More severe symptoms (marked pain, swelling, or early imaging changes) may require 4–6 weeks of non-weight-bearing with a boot or short leg cast, extended to 6–8 weeks for high-risk stress injuries. As pain improves, patients transition to partial weight-bearing, supportive footwear, and custom orthotics with metatarsal pads or rocker soles. Nonsteroidal anti-inflammatory drugs (NSAIDs) and icing are used in the acute phase, followed by physical therapy for range of motion, flexibility, strength, and gait mechanics [5]. Progress is monitored clinically and with periodic radiographs. Typical recovery involves 2–6 weeks of immobilization or protection, then gradual return to normal activity over several months, delaying high-impact activity until symptoms and exam findings resolve.

Smillie's classification system usually sees patients with stage 1 or 2 Freiberg's disease achieve complete symptomatic resolution through conservative treatment methods [6]. Patients with stage 1 or 2 disease who are still symptomatic after 6 months of conservative treatment, as well as those with advanced and long-standing disease, often require surgical intervention for ultimate treatment. Surgical procedures for treating Freiberg's disease can be divided into two categories: joint-preserving and joint-sacrificing procedures [7]. Joint-preserving operations include core decompression, open joint debridement, arthroscopic joint debridement, metatarsal osteotomies, and osteochondral autologous transplantation (OAT). Joint-sacrificing procedures, often reserved for later stages 4 and 5 of the disease, include interpositional arthroplasties and implant arthroplasties.

To address the ongoing lack of consensus regarding the optimal surgical approach for advanced-stage Freiberg's disease, one multicenter retrospective study investigated and compared the clinical efficacy and functional outcomes of dorsiflexion closing wedge metatarsal osteotomy (DCWMO) versus OAT [8]. Sixteen patients with Smillie stage 3 or 4 Freiberg's disease were included, with eight undergoing DCWMO and eight receiving OAT; each group was treated at separate institutions. Both procedures aimed to alleviate pain and restore function of the MTPJ, despite differing surgical techniques. DCWMO reoriented healthy cartilage via a dorsal wedge osteotomy, while OAT replaced necrotic cartilage with a graft harvested from the knee. Postoperative outcome measures included range of motion, complications, radiographic healing, and scores from the American Orthopaedic Foot and Ankle Society lesser MTP interphalangeal (AOFAS-LMI) score, visual analog scale (VAS), Foot and Ankle-Disability (FADI) score, and Short Form 12 (SF-12). Results showed that both techniques significantly improved pain and function. DCWMO rendered greater improvement in the AOFAS-LMI score, reflecting overall foot and ankle function, while OAT demonstrated superior outcomes in sports- and activity-specific scores (SFADI and AFADI) as well as significantly better plantarflexory ROM. No major complications were reported in either group, although DCWMO was associated with decreased plantarflexion and slight metatarsal shortening. The study concluded that both surgical options were effective; however, OAT might offer increased functional advantages in preserving joint mobility and athletic activity, while DCWMO might yield

better structural foot function in terms of higher FADI scores and reduction in the amount of plantarflexion deformity.

Conversely, there have also been discussions on recruiting soft tissue as a surgical modality versus solely relying on bony resection techniques. In response to the limited consensus regarding optimal surgical management for advanced-stage Freiberg's disease, a retrospective study was conducted to assess the long-term clinical and radiologic outcomes of interpositional arthroplasty utilizing the extensor digitorum brevis (EDB) tendon [9]. This retrospective case series aimed to evaluate the long-term radiological and clinical outcomes of interpositional arthroplasty using the EDB tendon for the treatment of advanced-stage Freiberg's disease. The study included 24 patients (19 females, five males) with Smillie stage 3–5 Freiberg's disease who underwent surgery between 2003 and 2015 after failing conservative treatment. The surgical technique involved harvesting the EDB tendon and inserting it within the MTPJ in order to alleviate pain and restore joint function. Patients were evaluated using the American Orthopaedic Foot & Ankle Society (AOFAS) score, VAS, radiographic joint space analysis, range of motion, and subjective satisfaction over a mean follow-up time of 133.8 months. Results showed significant improvements in AOFAS scores (from 53.9 to 80.3), MTPJ dorsiflexion (38.1° to 55.3°), and MTPJ plantarflexion (19.0° to 28.6°). No postoperative complications were noted. Radiographic analysis showed increased MTPJ space in all patients, and the mean postoperative VAS score was low (1.7 ± 0.9). Most patients reported being adequately satisfied with the outcome. The authors concluded that interpositional arthroplasty using the EDB tendon was an effective, safe long-term surgical option for treating advanced Freiberg's disease, offering significant functional improvement as well as pain relief.

The following report details a case of chronic Freiberg's disease that was ongoing for 10 years and was classified as falling between stages 3 and 4. The affected dorsal and central portions of the metatarsal head had collapsed, but the plantar articular surface remained intact. A dorsal wedge osteotomy would have been difficult in this presentation, and a total metatarsal head resection, typically reserved for stage 4 and beyond, was not discussed, as it could be performed as a future salvage procedure. This case report details a novel approach to Freiberg's disease utilizing a Valenti-type resectional arthroplasty of the affected metatarsophalangeal joint (MTPJ) while inserting a decellularized dermal graft to function as an interpositional joint spacer.

2. Case Presentation

A 23-year-old female presented on 5 May 2024 for initial evaluation of right foot pain. She was 5 feet 3 inches tall and weighed 230 pounds, with a BMI of 40.7. She complained of severe pain in her right foot for the past 10 years and was previously diagnosed with Freiberg's disease of the second metatarsal head by her primary care physician, as noted on imaging in April 2024 (Figure 1). Otherwise, she had an unremarkable past medical, social, and family history. The patient presented with a short-leg CAM walker and crutches, and stated that she was instructed to take NSAIDs and offload her foot by various physicians for the past decade. Previous offloading methods included a knee scooter and casting with crutches. She took ibuprofen 600 mg and acetaminophen 500 mg, as needed, to manage her daily pain. Intermittent use of a CAM walker and crutches for many years caused knee, hip, and lower back pain. She requested to discuss surgical management, as non-operative measures had failed over the previous 10 years.



Figure 1. Non-weight-bearing DP right foot X-ray demonstrating a flattened, collapsed second metatarsal head.

On physical exam, her neurovascular status was within normal limits, and severe pinpoint tenderness was noted at the head of the second metatarsal of the right foot. No remarkable edema was visualized throughout the forefoot. In addition, she had extreme pain with early extension and flexion of the second MTPJ. She could not tolerate the full range of motion of the second MTPJ due to pain. The patient was unable to bear weight on her feet or ambulate without her CAM walker due to severe pain and guarding.

An MRI obtained after the initial podiatry evaluation confirmed Freiberg's disease of the right second metatarsal head, which was classified as falling between Smillie stages 3 and 4 by the operating surgeon (Figure 2). The preoperative evaluation was done, and the patient provided consent for an ostectomy for osteonecrosis of the right second MTPJ, with the insertion of an acellular dermal allograft (ADA). The surgery was scheduled for 6 June 2024.



Figure 2. Sagittal T1-weighted magnetic resonance imaging of the right foot.

3. Surgical Technique

The surgery was conducted with the patient lying in the supine position. Local anesthetic of 1% lidocaine plain was administered, and the right ankle tourniquet was inflated prior to the start of the procedure. A longitudinal incision was made dorsally over the second MTPJ, medial to the extensor tendon. Blunt soft tissue dissection was performed to the level of the capsule to expose and free the second MTPJ. Joint mice, severe metatarsal head flattening, and arthritic changes were noted in the joint area (Figure 3).



Figure 3. Intraoperative exposure of the second MTPJ showing joint mice, severe metatarsal head flattening, and arthritic changes.

Loose, bony fragments were debrided and sent as pathological specimens. Under fluoroscopic guidance, a sagittal saw was used to resect osteonecrotic bone from the second metatarsal head in a dorsal-proximal to plantar-distal fashion at approximately 30 degrees of inclination. Following this, the saw was again utilized for a dorsal-distal to proximal-plantar osteotomy angled at 40 degrees from the base of the proximal phalanx, thereby completing a Valenti-fashion cut (Figure 4).



Figure 4. Dorsal-distal to proximal-plantar osteotomy angled at 40 degrees from the base of the proximal phalanx, Valenti-fashion cut.

The decellularized dermal graft was then folded into thirds and fitted into the bony deficit in the second MTPJ, measuring 1 cm long × 1.5 cm wide × 0.8 cm deep. The measurement of the graft was slightly overapproximated to account for post-implantation shrinkage. The sized graft was temporarily fixated with one simple stitch using 4-0 non-

absorbable suture to prevent unfolding. Multiple trials of graft implantation into the second MTPJ might be required for a satisfactory fit. Once achieved, the two superior corners of the dermal graft were permanently closed with a 4-0 non-absorbable suture (Figure 5). The dermal graft was then implanted into the second MTPJ (Figure 6). Then, it was finally secured to the joint capsule, followed by capsular closure with 2-0 absorbable suture (Figure 7).

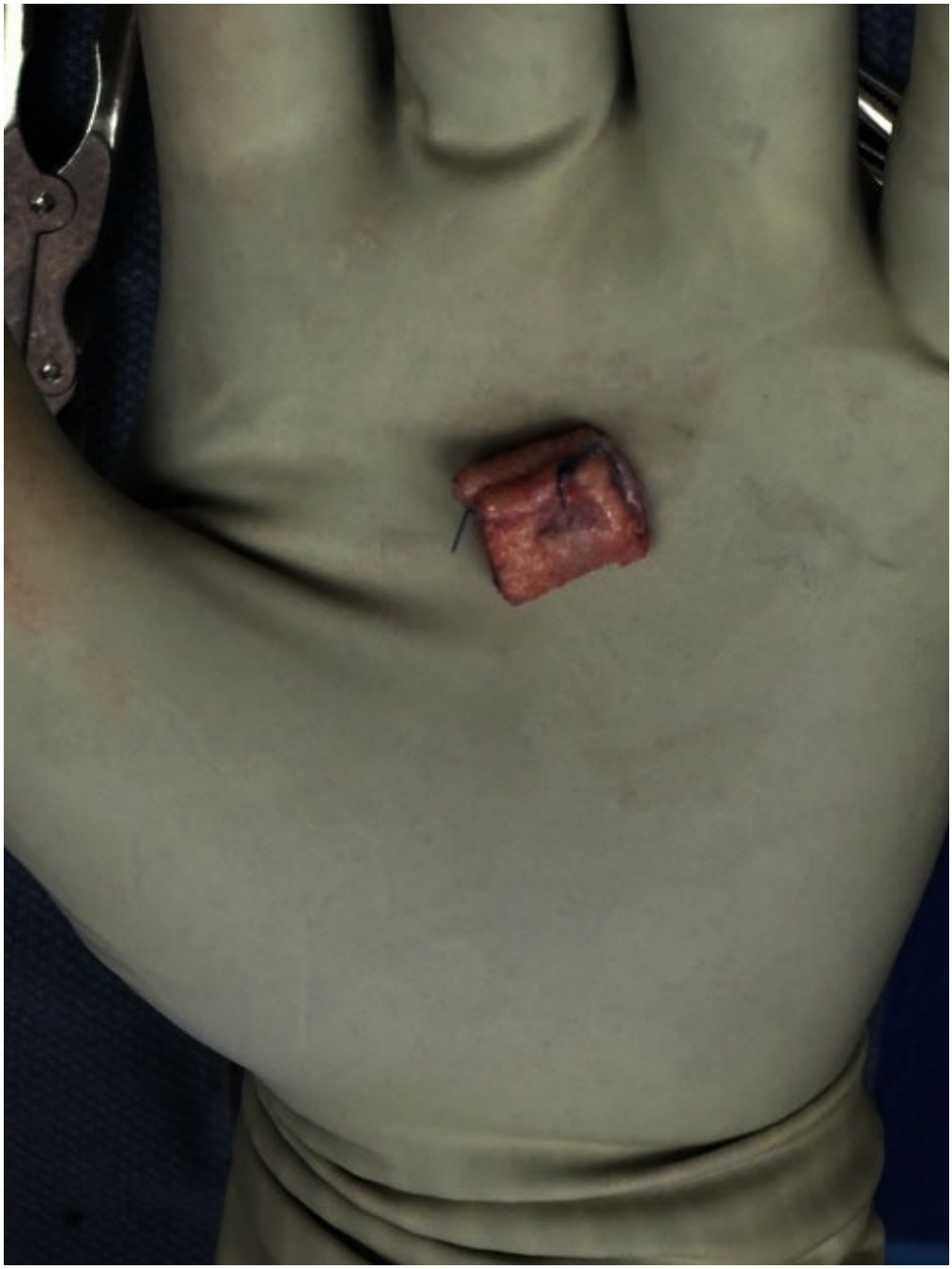


Figure 5. Final-sized graft fixated with 4-0 non-absorbable suture.



Figure 6. Dermal graft implanted into the second MTPJ.

Subcutaneous tissue and skin closure was completed in a sequential manner. Postoperatively, local anesthetic, consisting of plain 0.5% bupivacaine mixed with 1 cc of dexamethasone phosphate, was administered before the incision site was dressed using a povidone-iodine-soaked non-adherent dressing, 4 × 4 gauze, Kling, and an ACE bandage. The tourniquet was deflated, with an immediate return of a hyperemic response noted in all digits.

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Figure 7. Appearance of the second MTPJ with implanted graft after capsular closure with 2-0 absorbable suture.

4. Postoperative Course

4.1. Weight-Bearing Instructions

The patient was instructed to be non-weight-bearing while using a short-leg CAM walker and crutches for 2 weeks postoperatively. By 4 weeks after surgery, she was permitted to weight-bear as tolerated in the CAM walker and wean off crutches. This offloading period was critical in permitting the second MTPJ capsule and soft tissues to adequately envelop the ADA within the joint. Between weeks 4 and 6 post-surgery, the patient could begin transitioning out of the CAM walker and into a stiff-soled shoe. Ultimately, the goal was to resume all normal and athletic activity by week 8.

The patient in this case report ambulated in an offloading device for 10 years; therefore, no definitive expectation was provided for when she could ambulate in sneakers. She developed a functional limb length discrepancy due to utilization of a CAM walker for many years; this made her right lower extremity longer, causing imbalances in her knees, hips, and lower back. A physical therapy referral was ordered to aid in gait training and strengthening of the lower extremity and core muscles. Ultimately, the patient was able to ambulate in sneakers full-time at 16 weeks postoperatively.

4.2. Evaluation and Management

The patient was evaluated 1 week after surgery and, again, 2 weeks after surgery. Her skin was closed with absorbable sutures, but if non-absorbable sutures are used, they should be removed at 2 weeks. No range of motion or palpation of the second MTPJ was performed at these times, and the focus was only on the incision site. At the 4-week follow-up, the second MTPJ underwent gentle range of motion exercises; the patient noted no pain with either extension or flexion. Complete pain-free range of motion of the second MTPJ was observed. There was no pain with palpation of the second metatarsal head.

Resistance was applied to the second toe in both flexion and extension, and manual muscle strength was noted within normal limits.

At her 2-month postoperative follow-up, she demonstrated the ability to stand barefoot and perform a double-limb heel raise without discomfort in her right midfoot. No sagittal, frontal, or transverse plane deformities of the second digit were noted. In addition, no transfer lesions or tender callosities of the associated unaffected metatarsals were noted. An X-ray taken at this visit showed Valenti-type cuts at the head of the second metatarsal and base of the second proximal phalanx (Figure 8). However, she was unable to perform a right-sided single-limb heel raise due to weakness and discomfort. She could not walk more than 200 feet in sneakers due to her ongoing gait instability but denied having foot pain that limited her gait.



Figure 8. Lateral right foot X-ray 2 months postoperatively demonstrating Valenti-type cuts at the head of the second metatarsal and base of the second proximal phalanx.

At her 3-month postoperative visit, she denied sagittal, frontal, or transverse plane deformity of the second toe. No transfer lesions or tender callosities of the associated unaffected metatarsals were noted. An X-ray taken at the visit showed rounding and remodeling of the second metatarsal head (Figure 9). Furthermore, she could walk over 200 feet both in sneakers and while barefoot and was able to perform a right-sided single-limb heel raise without discomfort. She was discharged from physical therapy to a home exercise regimen because her gait abnormality and functional limb length discrepancy had improved significantly. At her most recent follow-up visits, 12 and 15 months after surgery, she remained ambulatory without any complaints or misalignment of her right second digit. She denied having any transfer lesions, calluses, or metatarsalgia of any of her sub-metatarsal head regions and noted a significantly improved quality of life, due to being able to weight-bear without discomfort.



Figure 9. DP right foot X-ray 3 months postoperatively demonstrating rounding and remodeling of the second metatarsal head.

5. Discussion

This case report detailed a successful, novel technique for addressing advanced-stage Freiberg's disease. A Valenti-style resectional arthroplasty of the affected MTPJ was performed while inserting a decellularized dermal graft to function as an interpositional joint spacer.

Several other alternative techniques have been described and studied previously in the literature in an attempt to investigate best practices for surgical management of Freiberg's disease. A more recent study proposed an evidence-based best practice treatment algorithm for Freiberg's disease based on current literature [6]. The treatment algorithm includes procedures through all stages of the disease and shows the progression from conservative joint-preserving procedures to the more aggressive joint-sacrificing procedures in the later stages of Freiberg's disease. The algorithm provides an overview by presenting all surgical options along with a stepwise approach based on the classification of disease. Our case involved a patient with Freiberg's disease classified between stages 3 and 4, and the use of our interpositional dermal graft fit directly within their ladder, under the stage 4 treatment algorithm.

This is the first study to report on the use of Valenti arthroplasty for surgical treatment of Freiberg's disease. In previous literature, the use of this technique was described as an intervention for hallux rigidus. A notable example is from 2019 when Colo et al. [10] published a study consisting of a systematic review of 327 hallux limitus/rigidus patients who underwent a Valenti arthroplasty. The results revealed that this procedure allowed for early recovery with few complications with regard to mobility and biomechanical stability when compared with first metatarsophalangeal fusion, interpositional arthroplasties, and other osteotomies. Similarly, the results can be applicable to the use of this arthroplasty in the treatment of end-stage Freiberg's disease. Despite its unconventional use in this case, its utility was clear in its ability to preserve plantar joint space, ray length, and the intrinsic plantar musculature compared with other techniques described previously.

Although the technique described was effective in this encounter, further research is required to evaluate the reproducibility of the positive outcome. Late-stage Freiberg's disease is relatively rare, since early detection and conservative management typically resolve the condition; thus, adding to the established literature pertaining to surgical management of late-stage Freiberg's disease may be challenging. In addition to more reports of successful outcomes with the described technique, a multicenter, randomized controlled trial comparing this technique with the standard of care would be beneficial to evaluate this procedure's effectiveness and reproducibility.

6. Conclusions

This case report highlights the potential for a Valenti-type resectional arthroplasty with dermal graft interposition as a joint-preserving solution for advanced Freiberg's disease. The graft maintained joint congruency, supported soft tissue remodeling, and provided an improved patient outcome via minimally invasive methodology. Furthermore, donor-site morbidity and altered biomechanics associated with traditional treatments were avoided. Although limited to one case, the functional outcomes suggest that this method may be a valuable addition to the existing surgical modalities for the treatment of stage 3–4 Freiberg's disease, particularly in young, active patients seeking joint preservation after failed conservative treatment. Larger studies are warranted to assess reproducibility and long-term durability.

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Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding authors.

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