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Is It Safe to Harvest a Large Segment of the Fibula as Part of Lower Extremity Limb Salvage: A Pilot Study to Determine Safety and Functional Outcomes in 5 Patients

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Abstract

Purpose: While fibular autografts have been increasingly utilized for limb-salvage reconstruction, the safety of harvesting a large fibular segment for lower extremity reconstruction remains unreported. This pilot study evaluates pain, donor-site morbidity, functional outcomes, and patient satisfaction following ipsilateral fibular strut autograft limb salvage reconstruction. **Method**: Five patients (mean age 55 years) underwent ipsilateral fibular strut autograft lower extremity limb salvage reconstruction by a single foot and ankle surgeon. Patients who had at least 14 months of follow-up were systematically selected and retrospectively reviewed. The mean harvested fibular length was 15 cm. Fibular segments were assembled in a "railroad" configuration, using 7 struts for TTC fusion and 2 - 3 struts for medial column reconstruction. Standardized four questionnaires, adapted from the AOFAS Ankle/Hindfoot scoring scale, were used to assess postoperative pain, function, donor-site morbidity, and satisfaction. **Results**: At final follow-up, no patient reported donor-site pain, weakness, or functional limitation. Three (60%) returned to normal activity, and two (40%) had "some difficulty" with ambulation; all showed improved gait. Four (80%) were satisfied with outcomes, and one was neutral. VAS pain scores ranged 0 - 3/10 in all cases. All patients achieved successful limb salvage and avoided major amputation. **Conclusion**: Harvesting a large ipsilateral fibular autograft (average 15 cm) for lower extremity limb-salvage reconstruction appears safe and does not compromise post-operative functional outcome.

Keywords

Fibula, Autograft, Strut, Limb Salvage, Reconstruction

1. Introduction

The fibula is the third longest bone in the human body. It plays a key role in providing ankle stability and serving as an attachment site for multiple ligaments and muscles. Unlike the tibia which bears approximately 93.6% of the total axial load, the fibula only transmits about 6.4% [1], indicating minimal impact on weight bearing. Because of its cortical strength, favorable geometry (long, straight and tubular shape), and biological potential, such as graft hypertrophy, particularly when vascularized, the fibular autograft has been increasingly utilized in limb-salvage reconstructive procedures [2].

Severe deformities including pes planus with elevated risk of talar extrusion, extensive (>80%) talar avascular necrosis, or large osseous defects secondary to trauma or osteomyelitis sometimes require large bone excision necessitating the use of a void filler, typically allogenic bone. Many studies have demonstrated that large segmental bone defects treated with allogenic bone have variable outcomes due to resorption of the graft or length of time for incorporation [3] [4]. Thus, in 2024, our team reported a novel reconstructive approach utilizing an ipsilateral fibular strut autograft to address these complex pathologies [5].

To date, no published studies have addressed safety of harvesting a large fibular segment in average 15cm for reconstruction. Therefore, our team conducted a pilot study to evaluate patient's satisfaction including functional outcomes in five patients who underwent ipsilateral fibular strut autograft procedures, each with a minimum follow-up of 14 months based on four standardized questionnaires. Our hypothesis is that harvesting a large fibular segment as a fibular strut autograft as part of limb salvage procedure is safe and does not adversely affect patients' functional outcomes postoperatively.

2. Method

In this pilot study, we systemically selected five patients that underwent reconstruction using a fibular strut autograft. In five patients, fibular strut grafts with lengths ranging from 9 cm to 21 cm were harvested. This was divided into 7 equal parts and collated into a column to replace the talus (**Figure 1**, **Figure 2**). In the case of filling a defect in the medial or lateral column, 2 - 3 struts were fashioned to fill the void present (**Figure 3**, **Figure 4**). In each case, the graft was employed to fill the osseous defect and/or to achieve limb lengthening. All procedures were performed by a single foot and ankle surgeon. The senior author typically performs 15 - 20 cases per year. Patients, who were lost to follow-up or had recently undergone surgery, were excluded from this pilot study. All procedures were performed for limb salvage purposes, as most patients in this cohort had previously been recommended for major amputation by other surgeons.

All selected patients received informed consent. Primary aim for this study is to evaluate patient's satisfaction including functional outcomes in five patients who underwent ipsilateral fibular strut autograft procedures, each with a minimum follow-up of 14 months. The ACFAS Ankle/Hindfoot score was intentionally

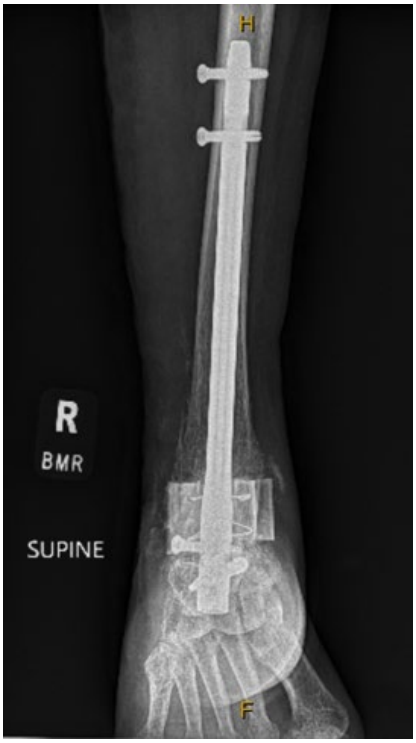

Figure 1. Radiographic image for tibiotalarcalcaneal fusion (TTC) with fibular strut autograft (AP view).

Figure 2. Radiographic image for tibiotalarcalcaneal fusion (TTC) with fibular strut autograft (Lateral view).

Figure 3. Radiographic image for medial column fusion with fibular strut autograft (Lateral view).

Figure 4. Radiographic image for medial column fusion with fibular strut autograft (AP view).

excluded from post-operative evaluation, as several parameters related to sagittal and hindfoot motion were not applicable in patients who underwent tibiotalocalcaneal (TTC) fusion and triple arthrodesis with medial column fusion. Instead, four standardized questionnaires were developed based on the AOFAS Ankle/Hindfoot scoring framework to provide a more representative assessment of clinical outcomes at the 14-month post-operative follow-up. These questionnaires evaluated the following domains: pain, functional status, donor-site morbidity, and overall patient satisfaction.

3. Result

This pilot study included five patients with a mean age of 55 years. The indications for surgery included severe pes planus with increased risk of talar extrusion, extensive (>80%) talar avascular necrosis, and large osseous defects secondary to osteomyelitis and trauma.

At a mean follow-up of 14 months, no patient reported donor-site pain, weakness, or functional limitation (Table 1). Three of five patients (60%) were able to perform daily activities without restriction, all of whom had exhibited antalgic gait prior to reconstruction (Table 2). Four of five patients (80%) reported satisfaction with the overall outcome (Table 3). At the most recent follow-up, postoperative pain scores ranged from 0 to 3 in all cases (Table 4).

Table 1. Donor site effect.

Question	None	Mild	Moderate	Severe
Do you experience any pain, weakness or difficulty at the site where your fibula was taken?	5/5	-	-	-

Table 2. Function.

Question	Not at all	Great difficulty	Some difficulty	Normal
How well are you able to walk or perform daily activities after your surgery?	-	-	2/5	3/5

Table 3. Satisfaction.

Question	Dissatisfied	Neutral	satisfied
How satisfied are you with the overall result of your surgery so far?	-	1/5	4/5

Table 4. Pain relief.

Question	0 - 3	3 - 5	5 - 7	7 - 10
How would you rate the pain in your reconstructed foot/ankle today compared to before surgery?	5/5	-	-	-

4. Discussion

Historically, non-vascularized fibular allografts have been used to reconstruct large segmental bone defects, especially in the upper extremity [6] [7]. Although the fibula carries only 6.4% of total axial load, its application in the lower limb has been limited due to concerns about graft fracture under physiologic weight-bearing, especially when used as a solitary load-bearing strut [6]. When utilized graft alone, nonunion rates were also reported to be high [8]. Subsequent incorporation

of corticocancellous autograft enhanced osteogenic potential and improved union outcomes [8]. Takano *et al.* (1993) achieved a 92% union rate using non-vascularized single fibular strut grafts for upper and lower limb reconstruction supplemented with iliac crest corticocancellous autograft, with fewer incidences of fibular graft fracture [8].

In foot and ankle surgery, particularly in ankle and tibiotalocalcaneal (TTC) arthrodesis, surgeons often employ vascularized fibular autografts in morselized, onlay, or inlay forms to enhance bone healing. However, most reports do not address reconstruction of large segmental defects. Atsira *et al.* described a cost-effective inlay technique with single fibular strut autograft for Charcot ankle reconstruction with a viable talus, achieving favorable short-term outcomes [9]. This approach, however, did not follow Sammarco's superconstruct principle of extending fusion beyond the injury zone, raising concerns about long-term outcome [10]. Some surgeons have also used fibular struts as biological intramedullary nails secured with screw fixation in cases of failed TTC nailing [11], and as structural buttresses in onlay techniques for primary ankle arthrodesis [12].

Our team previously reported a novel limb-salvage and lengthening technique utilizing an ipsilateral fibular strut autograft [5]. In that case, extensive talar excision was necessary due to avascular necrosis, resulting in a substantial osseous defect and limb shortening. The fibular strut autograft was configured using on average 7 equal segments to fill the defect and restore limb length. Two monofilament wires were placed through each of the segments in a "railroad" configuration and then gathered to create a single column (**Figure 5**). The wires were twisted on themselves to create a stable column with a central void to receive an intramedullary nail. The tibiotalocalcaneal (TTC) construct was then stabilized with an intramedullary nail. At one-year follow-up, the patient remained pain-free and had returned to normal daily activities.

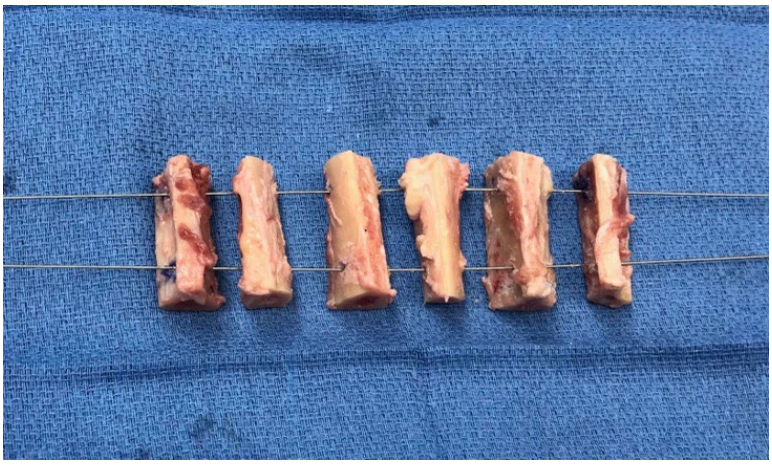

Figure 5. "Railroad" configuration to create a single column with fibular segments.

Following this case, we aimed to assess the functional outcomes and patient satisfaction associated with this technique, particularly given the excision of a

large segment of the fibula in average 15cm. Based on our questionnaire results, most patients expressed high satisfaction with the procedure. Preoperatively, all patients could not fully bear weight on the affected limb due to gait instability and or pain/deformity/dysfunction, however, postoperatively, the majority were able to bear full weight and ambulate on affected limb without gait instability and with minimal discomfort. Although some patients reported mild residual difficulties in their functional status, they demonstrated improved mobility compared to their preoperative status and successfully avoided major amputation. No donor-site complications were observed, and most patients remained pain-free at final follow-up. Therefore, we concluded that harvesting large fibula as fibular strut autograft can be considered as safe procedure in limb salvage reconstruction.

There are several limitations to our pilot study. First, this was a retrospective review, and therefore selection bias cannot be completely excluded. The ACFAS Ankle/Hindfoot score was not utilized intentionally, as many parameters were not applicable in patients undergoing tibiotalocalcaneal (TTC) fusion. To our knowledge, no prior pilot study has specifically evaluated the safety of using a large fibular segment as part of lower extremity reconstruction, and we believe this investigation provides valuable preliminary data in that regard. Future studies with larger cohorts are warranted to confirm these results.

5. Conclusion

This pilot study demonstrates that harvesting a large fibular autograft—averaging 15 cm—for limb salvage reconstruction appears safe in this small cohort and preserves postoperative functions. Patients reported no donor site morbidity, minimal pain, high satisfaction, and improved functional outcomes. All achieved successful limb salvage without major amputation.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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