Technical note

Minimally invasive harvesting of nonvascularized fibular graft in children

G. Lucas\textsuperscript{a, b}, J. Lopez\textsuperscript{a, b}, B. Fraisse\textsuperscript{a, b}, S. Marleix\textsuperscript{a, b}, P. Violas\textsuperscript{a, *, b}

\textsuperscript{a} Service de chirurgie pédiatrique, CHU de Rennes, 35033 Rennes, France
\textsuperscript{b} Faculté de médecine, université Rennes 1, 35043 Rennes, France

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Using a nonvascularized fibular graft is part of the therapeutic arsenal for filling bone loss defects. It is conventionally performed by open surgery. The authors propose a minimally invasive technique for harvesting a free fibular graft. The fibula was removed subperiosteally by two or three small incisions in five patients with a mean age of nine years and nine months. The mean surgical time was 21 min and 40.5\% of the length of the fibula was harvested. At the donor site, we found no removal-related complications, regeneration of the fibula was observed in 80\% of cases, and the cosmetic result was considered excellent by all patients with a mean 4.3 years follow-up. This minimally invasive technique is simple and fast, with very low morbidity in our experience.

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1. Introduction

The nonvascularized autologous bone graft has been used for more than 100 years, most particularly for reconstruction after resection of bone tumors [1], with the first use of a fibular graft described by Walter in 1911 [2]. The vascularized fibular grafting technique appeared in 1975 [3]. Using a nonvascularized fibular graft can provide an autograft for a variety of reconstruction surgeries [1, 4, 5]. Classically, nonvascularized fibula has been harvested via a large lateral approach of the leg. Herein we propose a minimally invasive technique.

2. Technique

Bone was harvested surgically on patients in the supine position with a pillow under the buttocks, with a tourniquet cuff in place. The site planned for the osteotomy (Fig. 1a) was at least 8 cm from the distal fibula (Fig. 1b) so as not to risk destabilizing the ankle. The proximal end of the fibula was at least 6 cm from the site to remain sufficiently distant from the fibular nerve (Fig. 1c). Two or three 2- to 3-cm incisions were required depending on the length of graft material needed, at least 10 cm apart (Fig. 1d). The fibular diaphysis approach was used after opening the crural fascia and identifying the space between the soleus and fibular muscles, followed by an incision of the periosteum and step-by-step subperiosteal detachment performed cautiously on each of the fibula surfaces using a spatula (Fig. 2a). Then the osteotomy was performed proximally and distally using an oscillating saw (Fig. 2b). The graft was grasped with clamps (Fig. 2c), then the graft was mobilized on its axis by rotating it, allowing the periosteum to be completely detached and the bone graft extracted (Fig. 2d). Postoperatively, crutches were prescribed with partial weight-bearing allowed as well as daily physical therapy with passive and active mobilization of the toes to prevent muscle and tendon retractions.

3. Preliminary series

Six nonvascularized fibula samples per minimally invasive approach were harvested between 2001 and 2012. One patient was excluded because her growth cartilages were closed. This series included five patients (three girls and two boys), with a mean age of nine years and nine months (range, 3–14 years). The indications were the following: two pelvic Ewing sarcomas, one ballistic injury to the proximal tibia (Fig. 3), one epiphysodesis of the femoral neck in a case of epiphysiolysis, and one anterior vertebral bone graft (Pott’s cervicothoracic abscess with kyphosis). The mean follow-up was 4.3 years (range, 1.3–10.5 years). The mean length of the grafts was 12.4 cm (range, 5–21 cm), a mean 40.5\% (range, 27–60\%) of the total length of the fibula. The mean duration of harvesting was 21 min (range, 17–30 min). No complications related to bone harvesting or surgical problems were noted. The esthetic aspect was deemed excellent by all the patients. No valgus ankle deformity or superior or inferior tibiofibular instability was recorded.
including in one patient presenting 4.5 mm ascension of the lateral malleolus. In four cases (80%), donor site regeneration was complete, within a mean five months (range, 1.5–8 months) (Fig. 4). In one case, regeneration occurred along the entire length of the fibula in 22 months but with nonunion at the proximal extremity, with the distal extremity achieving bone union after three years. At the last follow-up, in three cases, the width of the newly formed fibula was greater than it had been initially. The small number of patients examined in the study made it impossible to demonstrate a significant relation between the quality of fibular regeneration and patient age.

4. Discussion

The minimally invasive harvesting of nonvascularized fibula is a simple and rapid technique and appears to have very low morbidity. After bone harvest, complete regeneration was obtained in 80% of the cases, with one case evolving toward nonunion. In the literature, after open nonvascularized bone harvesting, Bettin et al. [6] found 49% complete regeneration in 8–16 months, with age seeming to be the only factor predicting regeneration. Setting the age limit at 15 years, prediction of regeneration reached 96% sensitivity and 74% specificity. Krieg et al. [1] found 69% complete
or partial regeneration. They also showed that patients with fibular regeneration were significantly younger, with a mean age of 16 years. Steinlechner et al. [7] found 86% fibular regeneration in eight children treated with sequestrectomy for chronic osteomyelitis. In view of the present results, a technical improvement could be suggested: using Liston forceps for the fibular osteotomy rather than an oscillating saw to prevent heating the bone, a possible cause of nonunion. Although Krieg et al. [1] reported 3.5% ankle instability with valgus deformity, we did not observe this complication, including in the case presenting a slight ascension of the lateral malleolus. In a series of 20 children, Fragnière et al. [8] found 45% valgus deformity and 100% lateral malleolus ascension, but these were vascularized fibula bone harvests. Only age was retained as a factor of valgus deviation. They therefore proposed prevention

Fig. 3. Ballistic injury, proximal tibia: a,b: postoperative; c,d: at 16 months of follow-up. Note the reconstitution of the fibula (thicker on lateral view).

Fig. 4. Fibula regeneration after minimally invasive bone harvesting: a,b: at 2 months of follow-up; c,d: at 10.5 years of follow-up.
using syndesmosis screws before 10–12 years of age. However, Hsu et al. [9] estimated that subperiosteal resection of nonvascularized fibula resulted in bone regeneration protecting from valgus deformity, which seems correlated with the results reported herein. In addition, several authors recommended preserving 6–8 cm of distal fibula to prevent destabilization of the ankle [3,10,11], despite the biomechanical work reported by Pacelli et al. [12] demonstrating that only 10% of the fibula length could be preserved. Bettin et al. [6] reported three cases of moderate laxity of the lateral collateral ligament at the knee.

Although no neurological complications were demonstrated, they have been reported in the literature. Shingade et al. [13] studied weakness in the extensor hallucis longus muscle after nonvascularized fibular harvest: 38% of the patients experienced postoperative weakness that resolved secondarily. Although it is often accepted that this weakness may result from disinsertion of the muscle origins after fibulectomy [14], Shingade et al. [13] showed that this weakness was isolated and related to impairment of the extensor hallucis longus nerve. After a cadaver study, they described several anatomic variants of the position of this nerve, sometimes very close to the periosteum of the fibula, which could therefore be injured during bone harvesting. Krieg et al. [11] reported 6.5% nerve lesions and Basarir et al. [15] described 10% paralysis of the fibular nerve that resolved spontaneously in four months.

Scarring complications after open harvesting have been reported. Bettin et al. [6] described 5.7% of patients with moderate pain, Krieg et al. [11] reported 3.5% muscle adherences related to scarring and 3.5% decreased ankle joint amplitudes. In 163 patients, Nassr et al. [16] found 15% experienced pain at the scar more than 3 months after surgery. Minimally invasive harvesting seems to prevent this complication.

5. Conclusion

If the option of a nonvascularized fibula graft is chosen, the minimally invasive bone harvesting procedure seems to be an elegant method with a good number of advantages, making it possible to harvest long grafts while reducing the procedure time, reducing intra- and postoperative bleeding as well as scarring complications with a clear esthetic benefit. Moreover, compared to the technique via a large lateral approach, we have encountered good results even if the number of cases studied has been small. Nevertheless, this technique requires thick periosteum that can be easily detached.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References