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## ORIGINAL ARTICLE

# Attaining tibiofibular union using an inter-tibiofibular autograft. A series of 43 cases

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## KEYWORDS

Non-union;  
Leg;  
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## Summary

**Introduction:** This study consisted of a series of 43 patients with lower leg non-union that were treated with an inter-tibiofibular autograft (ITFG).

**Material and methods:** After reviewing the surgical technique, the overall theory behind the treatment is described, including stabilization, soft tissue repair, infection control if necessary and then performing a procedure to help achieve bone union.

**Results:** After an average follow-up of 2 years, all the patients achieved union, but some required additional procedures. Only one patient had a delayed reactivation of the infection, which was successfully treated.

**Conclusion:** A broad set of indications for ITFG are proposed for lower leg non-union cases, in particular non-infected cases.

**Level of evidence:** Level IV. Retrospective study.

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## Introduction

The management of a post-fracture non-union of the lower leg is challenging, especially in the presence of an infection. The first surgical steps consist of debridement, stabilization and soft tissue repair. Infection control is imperative before any procedure to help with bone union can be performed [1,2].

Among the various proposed techniques, use of an autologous inter-tibiofibular graft (ITFG) can lead to very good results [1,3–6]. This autograft has well-known properties – osteogenic, osteoinductive and osteoconductive [3,7,8].

This technique induces very high levels of bone union, but it has not been evaluated in many published studies.

This retrospective study reviewed all of the ITFGs performed at HIA Percy (a military hospital in France) from 2001 to 2009. A total of 43 cases were included that had been operated on by the same team. The goal of this study was to extend the indications for ITFG to non-infected, non-unions of the entire lower leg axis.

## Material and methods

### Materials

This was a retrospective study on 43 patients operated with an ITFG at the Percy military hospital in France from 2001 to 2009. The series consisted of 38 men and five women

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(gender ratio of 7:1). There were an appreciable number of wounds caused by firearms or explosives (eight cases, 18.6%) because of the specific nature of our practice. The remainder of the patients had been injured in a motor vehicle accident (19 cases, 44%) or a work-related accident (six cases, 14%). The average patient age was 35.5 years (range 19–68). Of the 43 cases, there were 11 closed fractures (25.5%) and 32 open fractures (74.5%). The fracture was located in the upper third of the lower leg in three cases (7%), middle third in 21 cases (49%) and lower third in 19 cases (44%).

In the 30 cases of aseptic non-union (70%), there was a 5.8-month delay between the initial injury and the performance of the ITFG. These consisted of nine closed fractures (30%) and 21 open fractures (70%). These open fractures were classified as Grade I in four cases, Grade II in seven, Grade IIIa in four and Grade IIIb in six. As for the nine closed fractures, six were treated by nailing, one with a plate and two with a cast. Only one patient needed a coverage flap because of cutaneous wound dehiscence over the plate. Of the 21 open fractures, 19 were stabilized with an external fixator, one by nailing (Grade I fracture) and one by cast immobilization (Grade I). Seven required one or more coverage flaps. The average size of the bone defect in these aseptic non-unions was 0.47 cm (range 0.1–4 cm).

In the 13 cases of septic non-union (30%), there was a 15.3-month delay between the initial injury and the performance of the ITFG. These consisted of two closed fractures (15%) and 11 open fractures (85%). These open fractures were classified as Grade I in two cases, Grade II in one, Grade IIIa in one, Grade IIIb in five and Grade IIIc in two. Infection control was obtained through surgical debridement and antibiotics therapy for 3 months (6 weeks of intravenous administration followed by 6 weeks of per os administration). The two closed fractures were treated with plates and a coverage flap. The 11 open fractures were treated with an external fixator, except for one case that was treated by nailing (Grade I); nine cases required one or more coverage flaps. The average size of the bone defect in these septic non-unions was 1.29 cm (range 0.1–3 cm).

At the end, the average delay between the injury and ITFG in our series was 8.8 months, independent on the type of non-union. The average size of the bone defect was 0.72 cm. No reliable information on smoking habits was available.

### Surgical technique

The surgical technique chosen was based on surgeon preference. In our department, we preferentially use a cortiocancellous inlay graft combined with cancellous bone. The surgical approach was determined based on the patient's history, skin condition (scars, flaps, etc.) and arterial risk (preoperative arteriogram was not performed systematically). Our preferred approach was posterolateral. In our series, 27 patients were operated by the posterolateral route and 16 by the anterolateral route because of local findings (compartment syndrome, vascular problems).

The leg site was usually prepared first. The grafts were harvested from the anterior iliac crest if the patient was

in dorsal decubitus or from the posterior iliac crest if the patient was in ventral decubitus. Either cortiocancellous (34 cases) or cancellous (nine cases) bone grafts were harvested. Once the graft had been harvested, the wound was closed over a non-suction drain that was left in place for two to three days.

For the posterolateral approach, the patient was placed in ventral decubitus with the knee flexed to release the triceps surae. The skin incision was centered over the site of the non-union and over the fibula. It was extended beyond the site of the non-union by a few centimeters to provide better exposure. The periosteum was incised over the entire length of the skin incision. The dissection was continued below the periosteum and behind the fibula. The interosseous membrane was accessed in a non-injured area away from the non-union site. This membrane was a solid barrier on which the graft was later placed on. All the other muscles in the posterior compartment were spread using a bone rasp, which exposed the posterior sides of the tibia, fibula and interosseous membrane. The medial side of the fibula (hard to work with) and lateral side of the tibia were freshened using appropriate instruments (bone rasp, curette, rongeur). The cortiocancellous bone graft was shaped to match the desired height and inter-tibiofibular space. It was then embedded between the two bones. If cancellous bone grafts were used, they were placed on the interosseous membrane, and then the cortical graft was folded below it with its cancellous side facing the membrane. If embedding the graft only did not provide sufficient stability, tibiofibular K-wires were inserted behind the graft. The incision was closed over a suction drain; the fascia was not sutured.

For the anterolateral approach, the patient was placed in dorsal decubitus. The skin incision was centered over the site of the non-union and over the fibula. It was extended beyond the site of the non-union by a few centimeters to provide better exposure. The periosteum was incised over the entire length of the skin incision. The dissection was continued below the periosteum and behind the fibula. The tibialis anterior muscle was detached to expose the interosseous membrane. All of the muscles in the anterior and lateral compartments were spread to expose the site of the tibial non-union. Once the approach had been made, the surgery proceeded in a similar way to the previously described technique.

The surgical procedure was performed with single-dose antibiotic coverage in all cases and microorganism specific antibiotics when infections were discovered later on (seven cases). Return to weight-bearing was based on the stability of the construct and was either allowed immediately or delayed by two months.

### Review method

The clinical review method consisted of determining the maximum walking time, the presence of pain and the ability to return to sport. Range of motion of the entire leg was assessed, as was the local appearance. We used the Torabi classification [9] to compare our results with the various published series (Table 1).

**Table 1** Torabi scoring system.

	1	2	3	4	5	6
Pain	Severe, even at rest	Severe, prevents any activity	Tolerable, limited activity	After physical activity, disappears after resting	Slight or intermittent	None
Walking	Impossible without crutches	Significant limp	Slight permanent limp	Intermittent limp	Slight limp corrected with orthopedic footwear	Normal walking
Knee	Loss of 40° flexion	Loss of 30 to 40° flexion	Loss of 20 to 30° flexion	Loss of 10 to 20° flexion	Loss of 0 to 10° flexion	Normal knee
CPN	Secondary palsy	—	—	—	—	Normal CPN
Ankle dorsiflexion	Equinus foot	Dorsiflexion of 0 to 5°	Dorsiflexion of 5 to 10°	Dorsiflexion of 10 to 15°	Dorsiflexion of 15 to 20°	Normal
Ankle plantarflexion	Equinus foot 10° Mobility of 5°	Equinus foot 5° Mobility of 15°	Plantarflexion of 0 to 10°	Plantarflexion of 10 to 20°	Plantarflexion of 20 to 30°	Normal
Malunion	—	—	Valgus of 15° and slight recurvatum or valgus of 20°	Valgus of 10° or slight misalignment in the two planes	Subclinical valgus or varus or slight recurvatum	Normal alignment
Shortening	4 to 6 cm	3 to 4 cm	2 to 3 cm	1 to 2 cm	0 to 1 cm	None
Residual osteitis	Chronic fistula with no apparent sequestrum	Chronic fistula with visible sequestrum	Intermittent fistula	Trophic cutaneous problems	Unsightly scar	No sequelae

CPN: common peroneal nerve.

The radiologic review consisted of antero posterior (A/P) and lateral views and 3/4 views when needed to show the inter-tibiofibular space. The bone union time and the presence of graft remodeling were recorded. We defined bone union as the presence of a bone bridge over more than 50% of the tibia circumference and the absence of pain during weight-bearing reported by the patient (Figs. 1 and 2).



**Figure 1** External fixator.



**Figure 2** Inter-tibiofibular autograft (ITFG) at 12 months.

## Results

Other than two cases of phlebitis, there were no postoperative complications. The review occurred at an average of 21.7 months (range 6–84). Primary union occurred in 38 cases (88.3%). All the patients who achieved

bone union could walk and had full weight-bearing. Fourteen patients (37%) had residual pain at the old fracture sites. Nine patients (21%) had ankle stiffness (less than 10° of dorsiflexion) and three patients (8%) had a claw toe deformity. None of the patients reported pain sequelae from the iliac crest harvesting. There were 33 good or very good results (76.7%), with 15 of these patients (40.5%) having returned to sports; there were five average or poor results (11.6%) and five failures (11.6%) according to the Torabi classification. The average time to union based on X-rays in the 38 cases was 4.7 months (range 2–12).

## Discussion

This retrospective series included 43 patients. The number of patients and the gender ratio were consistent with other published series [2,3,6,10–18]. On the other hand, the average age (35.5 years) in our series was lower. This difference can probably be attributed to our patient recruitment and to the extension of the indications.

The suggested approach for delayed union with or without bone loss and with or without infection was been described by Dubrana et al. [19]. With no infection or bone loss, the problem is easy to solve—effectively stabilize the fracture site and restart osteosynthesis. With aseptic delay union, if there is a massive defect (greater than 10 cm), consider using massive cancellous bone autografts after adding a layer of bone cement. If the defect is less than 10 cm, we propose to always use an ITFG. During the November 2010 French Orthopedics and Traumatology Society (SOFcot) symposium, the bone defect was 7 cm long on average [20]. We extended our indications for ITFG, as this is the “winning surgical option” [19]. One of the advantages of an ITFG is its compatibility with all stabilization methods. Use of an external fixator for stabilization is consistent with the dynamic loading rules outlined by Meyrueis [6].

The presence of an infection makes the situation more complicated. Masquelet et al. [21] described a treatment sequence that is well standardized (infection control, soft tissue repair, and then union). The ITFG can help with bone union [19].

We only perform the ITFG once the bone has been reduced, the construct is stable and any potential infection has been controlled. Our approach is different from other published studies where the groups do not wait for the infection to drain [14]. Lortat-Jacob proposed a technique with a cancellous bone graft resting on the fibula [17,22]. It can be performed during the same procedure and does not require immediate skin closure. We believe that good quality soft tissue coverage is a prerequisite before any procedure is performed to help with bone union. Treatment of the bone infection requires a multidisciplinary approach [2,19]. The antibiotics therapy is continued for at least six weeks at effective doses [11,12,23].

Our preoperative assessments for the ITFG did not include arteriograms, although some believe it should be compulsory [6,18,22]. In fact, exposure of the inter-tibiofibular space during the surgical approach can lead to the compression of blood vessels and have serious consequences on the limb, where one of the two vascular systems is cut off.

Our surgical technique consisted of two surgical steps: collection of the graft and preparation of the host site. Some have advocated preparing the leg site before collecting the graft [14,16,18]. This would make it easier to determine how much bone volume is needed (although it has been said that we can never collect too much [17]) and to have a “fresh” graft that will be exposed to air and operating table lamps for the least amount of time, thus will not dry out [14,16]. The technical difficulty lies in determining the volume needed and especially the amount of filling required in the inter-tibiofibular space. The non-union site must be bridged by 1.5 times its width, which corresponds to about 2 cm. A 4 cm value was chosen during the SOFCOT symposium [20]. But such a large volume of bone graft at the site also makes embedding it difficult. In the distal tibia, the inter-tibiofibular space is quite narrow and in the proximal third, the presence of vascular and nerve pedicles makes this risky. We believe that the ITFG should not be placed too high, so as to avoid vascular and nerve complications. We propose using an arbitrary limit that corresponds to the metaphysis-diaphysis junction of the tibia.

There is unanimous agreement on the need for a continuous, stable fibula. We performed fibula fixation in five cases, to ensure that the fibula was stable and solid when the graft was placed on it. Others have proposed inter-tibiofibular fixation with two screws to improve the stability [2]. We have not used this stabilization method, but used K-wires in two cases. Embedding the graft brings stability to the site that, in theory, could then be treated with cast immobilization. If only cancellous bone grafts are used, another fixation method is required.

Some have proposed supplementing the ITFG with other clever technical tricks. Dubrana et al. proposed that, depending on if the non-union was infected or not, the ITFG be supplemented with additional cancellous bone grafts or even a second ITFG [19]. We agree with Brilhault who advocated not performing debridement of the non-union site [3]. This would destabilize the site and lead to devascularization. They were also apprehensive of medullary canal repermeability and are opposed to excising necrotic tissue at the site, except in the presence of an infection.

Intraoperative antibiotics were always used, solely to provide coverage during the surgical procedure. This was a single dose of a second-generation cephalosporin. In seven cases, additional antibiotics that were specific to the previously identified microorganism were given for 5 to 7 days in cases of pre-existing (but controlled) infection. We initially had 13 cases of infected non-unions, but only seven followed this protocol. These were seven Grade IIIB and IIIC fractures. Few studies deviate from our approach. One study systematically added a 6-day long antibiotic therapy [16], while one provided two weeks of treatment [2]. The later study was performed in the Congo, thus the local environment may have driven this combination. They also only considered using the ITFG once the infection had been controlled. There was only one case of reactivation of the infection; all the samples collected during the ITFG procedure came back negative, thus the infection had been controlled. Postoperative monitoring looked for the appearance of compartment syndrome, especially in the deep posterior compartment. Radiologic monitoring was initially

**Table 2** Primary failures.

Case no.	Site	Cutaneous opening	Initial fixation	Coverage flap	ITFG delay (month)	Pre-existing infection	Change to fixation	Type of graft	Length of bone defect
1	Lower quarter	IIIb	Ext. Fix	Yes	4	No	No	CS	Tight
2	Middle third	IIIb	Ext. Fix	Yes	6	Yes	No	CS	Tight
3	Lower quarter	No	Plate	Yes (necrotic scar tissue)	4	Yes	Yes, Ext. Fix	CS	Tight
4	Middle third	No	Nail	No	3	No	Yes, Ext. Fix	CS	5 mm
5	Middle third	IIIb	Ext. Fix	Yes	3	No	No	CS	5 mm

CS: corticocancellous; ITFG: inter-tibiofibular autograft.

difficult because the graft undergoes lysis before it reforms. Its appearance after 45 can be surprising to some.

The average time elapsed between the initial injury and the ITFG was 8.8 months. This is comparable to other published studies [2,6,11,12,14,16,18,24,25]. However, we noticed a significant difference in this delay when an infection was present. This can be easily explained by the need to control the infection before an ITFG can be considered. The average delay was 15.3 months in these cases, which is higher than reported in other studies [2,16]. The review was performed at 21.7 months on average, which is consisted with published reports. The average time to union was 4.7 months, which is much faster than in some studies [2,6,11]. This can probably be explained by the fact that we extended our indications for ITFG to aseptic non-unions.

The clinical criteria prosed by Torabi were used to classify our patients, which made it easier to compare our results to published reports [9]. There were five failures out of the 43 patients, thus a success rate of 88.3%. This rate is below the published rate of 90 to 100% [2,6,11,12,14,16,18,24,25]. With our five failure cases, four achieved union after a second ITFG procedure and the other one without any additional procedure. These were fractures of the middle third (three cases) and lower quarter (two cases) of the tibia, two of which were infected. The details of these five failures are given in Table 2. Patient 3 had a reactivation of the infection at 10 months after the ITFG. After two months of antibiotics therapy aimed at the same microorganism as the one initially identified, the infection resolved and union was achieved at 16 months after the ITFG.

There were no complaints or complications related to the graft donor site, although a rate around 26% has been documented [2,26]. We had no bone alignment problems at the final review, which differs with published reports [11,14,16,18]. We can explain this difference by the fact that the first priority was to reduce the fracture and achieve stable fixation before contemplating doing an ITFG. However there were a significant number of patients with ankle stiffness and even an equinus foot (seven cases, 16.2%). This rate is consistent with published reports [16] and can be explained by the duration of the external fixation (typically poor prevention of equinus) [14], the severity of the

initial injury [6] or the existence of tibiofibular synostosis [6,9]. This occurred in four middle third fractures, two lower third fractures and one upper third fracture of the tibia. There were three cases of claw toe deformity. We found no other published reports of this complication. After further analysis of the medical records, we believe these may have been cases of plantar or deep posterior compartment syndrome that went unnoticed and were later revealed through this claw toe deformity. Cases of deep posterior compartment syndrome are the hardest to diagnose. This can be explained by blood accumulating during a tibial fracture, with an increase in the muscular and hematic content, which is potentiated by an increase in pressure related to compression of the calf by its own weight onto the mattress. Although we initially suspected this was related to poor postoperative rehabilitation, this is was not the case. These cases involved fractures of the middle third and lower third of the tibia.

## Conclusion

Use of the ITFG technique led to excellent results. This was a reliable, simple and easily reproducible technique. Bone union was completely achieved in all cases. Previous activities, especially sports activities were restarted, even in this young population. The retrospective nature of the study was one of its most significant limitations. However, the length of the follow-up and the regular use of this procedure have led us to favor this technique and to extend its indications to non-infected non-unions going forward. In our opinion, the ITFG is the number one choice to ensure bone union.

## Disclosure of interest

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

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