Gap nonunion of tibia treated by Huntington’s procedure

Zile S Kundu, Vinay Gupta, Sukhbir S Sangwan, Pardeep Kamboj

ABSTRACT
Background: Gap nonunion that may occur following trauma or infection is a challenging problem to treat. The patients with intact or united fibula, preserved sensation in the sole, and adequate vascularity, were managed by tibialization (medialization) of the fibula (Huntington’s procedure), to restore continuity of the tibia. The goal of this retrospective analysis study is to report the mid-term results following the Huntington’s procedure.

Materials and Methods: 22 patients (20 males and two females) age 16-34 years with segmental tibial loss more than 6 cm were operated for tibialization of fibula. The procedure was two-staged in seven and single-staged in the rest 15 patients, where the lateral aspect of the leg was relatively supple. In the two-staged procedure, the distal tibiofibular synostosis was performed six-to-eight weeks after the proximal procedure. Weightbearing (protected) was started in a long leg cast after six-to-eight weeks of the second stage and continued for six-to-eight months, followed by the use of a brace.

Results: The fibula started showing signs of hypertrophy within the first year after the procedure and it was more than double in breath after the four-year period. Full and unprotected weightbearing on the operated leg was achieved at an average time of 16 months. At the final followup, ten patients were very satisfied, seven satisfied, and five fairly satisfied. One patient had persistent nonunion at the proximal synostotic site even after bone grafting and secondary fixation.

Conclusion: Huntington’s procedure is a safe and simple salvage procedure and remains an excellent option for treating difficult infected nonunion of the tibia in the selected indications.

Key words: Gap nonunion, tibia, tibialization of the fibula

INTRODUCTION

Gap nonunion presents a major challenge to the orthopedic surgeon, especially when associated with infection, old or active osteomyelitis, and multiple previous surgeries. Management of the gap nonunion is technically difficult, time-consuming, physically and psychologically demanding for the patient with unpredictable clinical outcome. The problem involves bridging or regenerating areas of bone loss while maintaining limb length and alignment. Open fractures with bone loss are most common in the tibia due to its subcutaneous anatomical site, and a number of patients have secondary bone loss after surgical debridement of the necrotic bone or osteomyelitis. Nonunion with infection, bone loss, or both, represents a more complex problem and is better managed with a vascularized fibular graft, free fibular graft, bone transport, or sometimes even amputation. The nonunion may persist despite a series of reconstructive procedures, with external fixation, internal fixation (plate or intramedullary rods), bone grafting, plastic surgery, and Ilizarov frame application. The patient may require multiple surgeries and sometimes the surgeon is left with no option, but secondary amputation or disarticulation.

Transposition of the ipsilateral fibula to the tibia (fibula pro tibia) was suggested by Hahn in 1884, and was first used successfully by Huntington in 1903. Subsequently, several authors have used fibular centralization in cases of posttraumatic and post-infective tibial defects, osteomyelitis, congenital deformity, and tumors. The fibula is mainly a cortical bone and provides mechanical strength. In this procedure, the fibula is transferred to the tibia as a pedicle graft. Due to retained blood supply to one end of the transplant, the graft easily takes up and hypertrophies upon weightbearing over a period of time.
The aim of this retrospective analysis is to report the midterm results, problems and obstacles with ipsilateral fibular transposition for reconstruction of tibial defects.

**Materials and Methods**

We retrospectively reviewed the results of 22 patients operated with tibialization of the fibula, operated between 1998 and 2008. All these patients had segmental tibial loss (more than 6 cm) that occurred due to open fracture of the tibia (n=14), chronic hematogenous osteomyelitis with or without sequestrum (n=3) and following failed/infected previous implant surgery in closed fracture of tibia (n=5). All these patients had intact or well-united fibula and intact sensation in the sole of the foot. There were 20 males and two females with a mean age of 26.8 years (range 16 – 34 years). Average time of the Huntington’s procedure after the initial trauma was 20 months (range 15-30 months). All the patients were subjected to the routine investigations for pre-anaesthetic checkup and the X-rays of the affected leg.

Initially sequestrum and dead necrotic bone were removed and infection was managed by debridement and antibiotics. All the operations were performed under general (n=7) or regional anesthesia (n=15). Seven patients had two-stage procedures and in the remaining cases it was a single-stage procedure. Initially sequestrum and dead necrotic bone were removed and infection was managed by debridement and antibiotics. If soft tissues were adequately supple, a single-stage surgery was performed, whereas, in the presence of extensive scarring, particularly in the lateral compartment of the leg, a two stage surgery was preferred. In the two-stage procedure, the proximal end was tibialized in the first stage and the second stage was performed after six-to-eight weeks.

Through a lateral incision, 3–4 cm of the proximal fibula was exposed subperiosteally, above the level of the distal part of the proximal tibial fragment. The peroneal nerve was not dissected routinely, except in two cases, where the site of the nonunion was in proximal one-third of fibula. Through another anterior one-and-a-half-inch long incision, the distal lateral part of the proximal tibia was exposed and a shallow trough was made on this surface to fit the fibula for better contact. The muscle and neurovascular structures in the anterior compartment were retracted anteriorly and the fibula was shifted into the trough and stabilized with two-to-three 4.5 mm (n=16) cortical screws or 4 mm (n=3) cancellous screws or Kirschner’s wires (n=3). In the single-stage procedure, 3–4 cm of the distal fibula was also exposed subperiosteally below the level of the proximal part of the distal tibial fragment, through a lateral incision. Through another 4-cm long anterior incision, the lateral surface of distal tibial fragment was exposed 2 – 3 cm below its tip, and a trough was made for fitting the fibula after lifting the neurovascular bundle and muscles anteriorly. It was stabilized using two-to-three 4.5 mm (n=16) cortical screws or 4 mm (n=3) cancellous screws or Kirschner’s wires (n=3). In two cases where the distal tibial fragment was small, an intramedullary pin through the calcaneum, subtalar joints and ankle joint was used to fix the distal end of the fibula and apex of the distal tibial fragment. The soft tissue and skin were sutured and a well-padded plaster cast was applied from the groin to the toe, with the knee in 5° – 10° flexion, the ankle in 5° external rotation, and the foot in the neutral position or as much dorsiflexed as possible, in cases where there was equinus deformity. Weightbearing was not allowed in the first eight weeks. The stitches were removed after three weeks and the cast was reapplied.

Guarded weightbearing was started eight-to-ten weeks onward, when the radiological union was observed, and a full leg cast was converted to below leg cast after 16 – 20 weeks. Patients were followed up regularly and assessed clinicoradiologically for bone union, infection, and complications like nonunion of synostosis, implant failure, fracture of fibula, and so on. Bony union was said to have occurred when the authors observed the osseous bridging (uninterrupted external bony borders) between the fibula and tibia at the synostotic site, with no evidence of gap, in both the anteroposterior and lateral views of the X-rays. Patient satisfaction was assessed using a four-level scale (Subjective assessment was done whereby the patients were asked about their satisfaction level with the final outcome) i.e. whether they were very satisfied, satisfied, fairly satisfied or dissatisfied; and the pain score was assessed using a 10-point Visual Analog Scale (VAS), where 1 represented no pain and 10 unbearable pain. In addition the range of motion in the knee and ankle joint, with the associated deformities and shortening, were also taken into account.

**Results**

The patients had nonunions with gaps ranging from 6 to 16 cm (mean 11.3 cm). Fourteen patients had open tibial fractures, three had the sequelae of chronic osteomyelitis, and five had infected nonunion after nailing / plating for closed tibial fractures, requiring removal of the boney segments. In seven patients two-stage procedures were done, where the proximal fibula was shifted at the first stage, followed by a second-stage surgery, after six-to-eight weeks in the distal end. The mean followup after fibular transposition was 5.38 years (range 3 – 10 years). The mean leg length discrepancy / shortening was 4 cm (range 2 – 9 cm) and the patients were advised suitable shoe raise for...
ambulation. In five patients, the ankle motion was impaired due to mild equinus deformity. The axial alignment was normal in 18 patients. Asymptomatic valgus and varus deformities were observed in two patients each. None of the patients had extensor lag. The mean flexion at knee was 110° (range 100°-130°). The mean pain score was 3 (range 1-7). 21 patients achieved union at both the proximal and distal ends. One patient had nonunion at the proximal synostotic site, even after grafting and refixation. However, this patient was mobile with brace and crutches. The average time of union was 12.8 weeks (range 8-21 weeks). Full weight bearing on the operated leg with (n=14) or without (n=8) walking aids, was achieved at average 16 months (range 12-30 months). Radiographically, hypertrophy of the grafted fibula was observed in all the patients, and in some cases (n=5), the grafted fibula was as thick as the tibia on the opposite side [Figures 1 and 2]. The infection healed in all but one patient, who had some drainage on and off. In one patient, screw cut out occurred from the proximal tibiofibular junction. The patient was re-operated upon and fixed with a thin diameter intramedullary rush nail, along with cancellous bone grafting. Another patient had screw cut out at the distal end, but could be managed well in the plaster and had malunion [Figure 3]. One patient had a fractured fibula after full weightbearing, which was managed conservatively with an above-knee cast, and was united in a four-month period. No patient had compartment syndrome or neurovascular damage.

Figure 1: Roentgenograms showing (a) anteroposterior and lateral views a big gap in the tibia; (b) The fibula was approximated and compressed to tibia above and below the defect with screws; (c) Hypertrophy of the fibula after six years, almost three times the original girth of the fibula (d) Clinical photograph of patient showing weight bearing on hypertrophied fibula

Figure 2: Roentgenograms showing (a) anteroposterior view a large gap in distal tibia and nonunion of fibula with deformity; (b) Fibula medialized to tibia above the defect with two screws and in the distal part the deformity was corrected, bone grafted, and stabilized with Kirschner wires (removed in followup as they became symptomatic); (c) Hypertrophy of fibula after seven years; (d) Clinical photograph of same patient showing full weight bearing on hypertrophied fibula
Most of the patients were able to perform their day-to-day activities and routine work, although with some restriction in running, climbing stairs, and doing strenuous work. No significant difference was found in terms of union, fibular hypertrophy, complications, patient satisfaction, and time of weightbearing, in patients with single-stage versus two-stage surgery. At the final followup, ten patients were very satisfied, seven satisfied, and five fairly satisfied [Table 1]. The results were evaluated on the basis of our observation that the patients with no pain, more walking distance without aid, less limb length discrepancy, good ankle and knee movements, and performing routine activities efficiently were more satisfied and vice versa.

**DISCUSSION**

Gap nonunion of the tibia with infection and extensive scarring creates a challenging clinical situation for treatment. The tibia is affected more than the fibula, because of its subcutaneous location, leading to either loss of segment or requiring removal of necrotic bony segment in the process of the treatment, the fibula, being covered by muscles all around, usually escapes segmental loss and also unites easily and takes its continuity back. The option for treatment of such injuries includes a Papineau type of cancellous bone grafting in patients with bone gap less than 4 cm, non-vascularized fibula graft from contralateral leg, microvascular fibular transfer, Huntington’s procedure, and Ilizarov technique. The cancellous bone used in the Papineau’s procedure provides limited mechanical strength.\(^9,12,13\) The Ilizarov technique involves bone transfer and compression-distraction to stimulate the nonunion site. It is a prolonged, time-consuming procedure, with its own complications and

| Age (years) and sex | Site | Cause | Gap (cm) | Proximal implant | Distal implant | Previous surgery | No. of stages | Union Weeks | Functional results | Complications | Follow up months |
|---------------------|------|-------|----------|------------------|----------------|------------------|---------------|-------------|-------------------|---------------|------------------|
| 20 Male             | M    | A     | 6        | Screw           | Screw          | 2                | S             | 10          | VS                | -             | 38               |
| 24 Male             | M    | A     | 8        | Screw           | Screw          | 3                | S             | 8           | VS                | -             | 72               |
| 28 Male             | M    | C     | 10       | Screw           | Screw          | 2                | S             | 16          | VS                | -             | 96               |
| 30 Male             | M    | A     | 10       | Screw           | K wire         | 2                | T             | 13          | S                 | Infection     | 40               |
| 21 Male             | M    | A     | 12       | Screw           | Screw          | 3                | S             | 10          | S                 | Equinus deformity | 48               |
| 16 Male             | M    | B     | 12       | Screw           | Screw          | 2                | T             | 10          | FS                | -             | 50               |
| 33 Male             | M    | C     | 15       | Screw           | Screw          | 3                | T             | 18          | S                 | Equinus deformity | 44               |
| 34 Male             | D    | A     | 14       | Screw           | K wire         | 1                | S             | 14          | VS                | -             | 84               |
| 27 Male             | M    | A     | 16       | Screw           | Screw          | 1                | S             | 13          | FS                | -             | 36               |
| 25 Male             | M    | B     | 10       | Screw           | Screw          | 2                | T             | 10          | S                 | Screw back-out | 48               |
| 28 Female           | D    | A     | 13       | Screw           | Rush nail      | 3                | T             | 21          | FS                | Equinus deformity | 96               |
| 25 Male             | M    | A     | 14       | Screw           | Screw          | 3                | T             | 17          | S                 | Equinus deformity | 100              |
| 29 Male             | M    | C     | 7        | K wire          | Screw          | 1                | S             | 9           | VS                | -             | 38               |
| 30 Male             | M    | A     | 13       | Screw           | Screw          | 1                | S             | 14          | FS                | -             | 120              |
| 33 Male             | P    | A     | 12       | Rush nail       | Screw          | 2                | T             | 13          | VS                | -             | 60               |
| 36 Male             | M    | A     | 11       | Screw           | K wire         | 2                | S             | 14          | VS                | -             | 90               |
| 32 Male             | P    | A     | 12       | Screw           | K wire         | 1                | S             | 13          | VS                | -             | 60               |
| 35 Male             | M    | C     | 12       | Screw           | Screw          | 1                | T             | 10          | S                 | -             | 36               |
| 25 Male             | M    | A     | 16       | Screw           | K wire         | 1                | T             | 16          | FS                | Equinus deformity | 50               |
| 24 Female           | M    | C     | 8        | Screw           | Screw          | 1                | S             | 11          | VS                | -             | 84               |
| 18 Male             | M    | A     | 12       | Screw           | K wire         | 2                | S             | 13          | S                 | Screw back-out | 84               |
| 17 Male             | M    | B     | 6        | Screw           | Screw          | 2                | S             | 8           | VS                | -             | 48               |

M = middle third, P = proximal third, D = distal third, S = single-stage procedure, T = two-stage procedure, VS = very satisfied, S = satisfied, FS = fairly satisfied, cm = centimetres, K = Kirschner A = open tibial fracture, B = osteomyelitis, C = secondary infection in closed tibial fractures

Figure 3: (a) Roentgenogram anteroposterior and lateral views (b) clinical photograph of same patient showing complication as cut out of screw in a patient with a big tibial gap
obstacles. Although early weightbearing is possible, and proper realignment of the limb can be achieved, the major drawback of this technique is that prolonged endurance with frame, is not very well accepted by patients with a significant pin track infection rate. The use of a free-vascularized fibular transfer from the contralateral limb adds morbidity to the normal limb, is time-consuming, and requires a specialized microsurgical team, which may not be available even in major centers. In extensively scarred tissue, considerable dissection of the posterior and lateral compartments to isolate the peroneal vessel is problematic and its anastomosis in such a leg is a gigantic task. Free fibular graft from the opposite side leg, in the presence of sepsis, may necrose and even if it survives, it will take a very long time to heal, with a poor functional outcome. Additionally there is donor site morbidity. The use of the avascular strut allograft is often limited by the available length of the resection, risk of nonunion, fracture, and infection, besides the fear of disease transmission. The presence of infection and extensive soft-tissue loss can be a serious threat to the viability of the limb. However, there has been much debate on the long term disability after amputation, as well as the cost of repeated prostheses.

There are many advantages of this procedure. Medialization of the ipsilateral fibula (Huntington’s procedure) can be performed by a trained orthopedic surgeon even in hospitals with moderate infrastructure. A large graft of the ipsilateral fibula raised on a pedicle of the peroneal artery, aligned and fixed to the tibia in its posterior long axis, provide a sound mechanical and biological basis for the union. The fibula is surrounded by muscles all around and has abundant vascular supply from the nutrient branch of the peroneal artery and circular anastomosis of the musculoperiosteal vessels, which supports in its hypertrophy and union at the synostotic site. When the fibula is subjected to more than normal weightbearing stresses, it undergoes hypertrophy and becomes an integral part of the static supporting architecture of the leg. The fibula placed centrally in the weightbearing axis in the medullary cavity of the tibia seems to be more biomechanically sound than synostosis of the fibula to the tibia in its lateral eccentric position, both in children and adults. However, in patients with extensive scarring and fibrosis, it is too difficult to mobilize the fibula centrally, without excessive periosteal stripping, thus jeopardizing the blood supply. Furthermore, there is no need to touch or handle the scarred or infected gap area, as surgical incision and procedure is restricted away from the infected nonunion site. Even the area of circumferential scarring can be left as such, without performing a substantial plastic procedure like free flap or cross leg flap. Ipsilateral fibular transfer is an easy, simple, inexpensive biological procedure that does not require microvascular skills. The reduction in volume of the lower leg that follows the anteromedial shift of the fibula makes skin closure easier, even in cases with scarred tissue. The procedure is restricted to the same limb, unlike those cases in which the opposite fibula is used as a vascularized graft. This helps reduce morbidity. The shorter operating time and the fact that the graft retains its blood supply may help to reduce infection, improving its chances of union and accelerating the process of hypertrophy.

Huntington in 1944 popularized a procedure for treatment of tibial defects in children, which he described it as a two-stage procedure. We opted for this procedure as a last resort and had good success in salvaging the limbs. In more than half of the cases we could perform the procedure in one stage, where there were supple soft tissues on the anterolateral part of the leg. However, in cases of circumferential scarring and scarification on the anterolateral part, a two-staged procedure was preferred, as the fibula would need extensive release from the lateral surface, jeopardizing its blood supply. If it was medialized in the presence of a scar in this area there were chances of screw cut outs, which occurred in two patients in our series. In adults the hypertrophy of the fibula usually took a long time, as compared to children. Therefore, they needed prolonged protective weightbearing. They were advised to use a leg brace along with a stick, till union between the fibula and tibia occurred.

Some shortening of limb persisted in almost all cases. In spite of shortening, the procedure provided acceptable function to many patients and served as a good enough alternative to amputation, where there was adequate vascularity and intact sensation in the sole. Another drawback of this procedure was that these patients were not able to participate in strenuous activities like sports, due to the risk of fractures and a shortened limb, but they could do all their routine work at farms and public transportation, without the help of walking aids. Since these cases have severe bone loss in scarred extremity, hence even after other procedure they may still not be able to participate in sports. Limb-salvage surgery had psychological and cosmetic advantages over amputation and might be the preferred treatment option in selected individual patients.

Conclusion

The Huntington’s procedure is still a viable option for salvaging gap nonunions of the tibia. The use of fibular grafts in the management of defects of long bones is a relatively straightforward procedure, requiring no microsurgical expertise. This procedure is effective, but for optimal results the treatment needs to be individualized by the treating surgeon, with due consideration of soft tissue coverage, socioeconomic factors, and the available expertise.
REFERENCES

1. Lifeso RM, Al-Saati F. The treatment of infected and uninfected nonunion. J Bone Joint Surg Br 1984;66:573-9.
2. Keating JF, Simpson AH, Robinson CM. The management of fractures with bone loss. J Bone Joint Surg Br 2005;87:142-50.
3. Ryzewicz M, Morgan SJ, Linford E, Thwing JI, de Resende GV, Smith WR. Central bone grafting for nonunion of fractures of the tibia: A retrospective series. J Bone Joint Surg Br 2009;91:522-9.
4. Wiss DA, Stetson WB. Tibial nonunion: Treatment alternatives. J Am Acad Orthop Surg 1996;4:249-57.
5. Hahn E. Eine methode, pseudarthrosen der tibia mit grossen knockendefekt zur heilung zu bringen. Zentralbl f Chir 1884;11:337-41.
6. Huntington TW. VI. Case of bone transference: Use of a segment of fibula to supply a defect in the tibia. Ann Surg 1905;41:249-51.
7. Agiza AR. Treatment of tibial osteomyelitic defects and infected pseudarthroses by the huntington fibular transfer procedure. J Bone Joint Surg Am 1981;63:814-9.
8. Meyerding HW, Cherry JH. Tibial defects with nonunion treated by transference of the fibula and tibiofibular fusion. Am J Surg 1941;52:397-404.
9. Kassab M, Samaha C, Saillant G. Ipsilateral fibular transfer in tibial nonunion using huntington procedure: A 12-year followup study. Injury 2003;34:770-5.
10. Puri A, Subin BS, Agarwal MG. Fibular centralisation for the reconstruction of defects of the tibial diaphysis and distal metaphysis after excision of bone tumours. J Bone Joint Surg Br 2009;91:234-9.
11. Tan JS, Roach JW, Wang AA. Transfer of ipsilateral fibula on vascular pedicle for treatment of congenital pseudarthrosis of the tibia. J Pediatr Orthop 2011;31:72-8.
12. Papineau LJ. Excision-greffe avec fermeture retardée délibérée dans l’ostéomyélite chronique. Nouv Presse Med 1973;2:2753-5.
13. Papineau LJ, Alfageme A, Dalcourt JP, Pilon L. Ostéomyélite chronique: Excision et greffe de spongieux à l’air libre après mises à plat extensives. Int Orthop 1979;3:165-76.
14. Paley D, Catagni MA, Argnani F, Villa A, Benedetti GB, Cattaneo R. Ilizarov treatment of tibial nonunions with bone loss. Clin Orthop Relat Res 1989;241:146-65.
15. Paley D. Problems, obstacles, and complications of limb lengthening by the ilizarov technique. Clin Orthop Relat Res 1990;250:81-104.
16. Weiland AJ, Daniel RK. Microvascular anastomoses for bone grafts in the treatment of massive defects in bone. J Bone Joint Surg Am 1979;61:98-104.
17. al-Zahrani S, Harding MG, Kreml M, Khan FA, Ikram A, Takroni T. Free fibular graft still has a place in the treatment of bone defects. Injury 1993;24:551-4.
18. de Boer HH, Wood MB, Hermans J. Reconstruction of large skeletal defects by vascularized fibular transfer. Factors that influence the outcome of union in 62 cases. Int Orthop 1990;14:121-8.
19. Ramseier LE, Malinin TI, Temple HT, Mnaymneh WA, Exner GU. Allograft reconstruction for bone sarcoma of the tibia in the growing child. J Bone Joint Surg Br 2006;88:95-9.
20. Chacha PB, Ahmed M, Daruwalla JS. Vascular pedicle graft of the ipsilateral fibula for nonunion of the tibia with a large defect. An experimental and clinical study. J Bone Joint Surg Br 1981;63:244-53.
21. Taylor GI, Miller GD, Ham FJ. The free vascularized bone graft. A clinical extension of microvascular techniques. Plast Reconstr Surg 1975;55:533-44.
22. Shapiro MS, Endrizzi DP, Cannon RM, Dick HM. Treatment of tibial defects and nonunions using ipsilateral vascularized fibular transplantation. Clin Orthop Relat Res 1993;296:207-12.
23. Tuli SM. Tibialization of the fibula: A viable option to salvage limbs with extensive scoring and gap nonunions of the tibia. Clin Orthop Relat Res 2005;431:80-4.
24. Krieg AH, Hefii F. Reconstruction with nonvascularised fibular grafts after resection of bone tumours. J Bone Joint Surg Br 2007;89:215-21.

How to cite this article: Kundu ZS, Gupta V, Sangwan SS, Kamboj P. Gap nonunion of tibia treated by Huntington’s procedure. Indian J Orthop 2012;46:653-8.

Source of Support: Nil, Conflict of Interest: None.