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ORIGINAL CLINICAL ARTICLE

Donor site morbidity following the harvesting of cortical bone graft from the tibia in children

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Abstract

Introduction Since the nature of complications following the harvesting of bone from the tibia in children is not well documented in the literature, we undertook this study in order to determine the frequency and nature of donor site complications following the harvesting of large cortical strut grafts from the tibial diaphysis in children.

Materials and methods During the past 19 years, tibial cortical grafts were harvested from 47 children on 77 separate occasions, mainly for the treatment of congenital pseudarthrosis of the tibia. The technique of graft harvesting was identical in every case. Case records of these 47 children were reviewed. Forty of these children were reviewed at a mean period of 5.5 years.

Results No immediate post-operative complications were noted and, at follow-up, apart from mild bowing of the anterior cortex of the tibia, no deformities were encountered. The tibial cortex reformed completely and this facilitated repeat graft harvesting when required. The only major complication was a stress fracture of the tibia in one boy.

Conclusion Harvesting cortical bone graft from the tibia is simple and is fraught with negligible morbidity.

Keywords Autogenous bone graft · Donor site morbidity · Tibial bone graft · Cortical bone graft

Introduction

The type, quality and source of autogenous bone graft needed for reconstructive surgery in paediatric orthopaedics vary. Cancellous and cortico-cancellous bone is most frequently harvested from the ilium, while the fibula and ribs are common sources of vascularised and non-vascularised strut grafts. The use of tibial strut grafts has been reported less frequently [1–5].

Donor site morbidity and complications following the harvesting of bone from the iliac crest and the fibula have been well documented [6–14]. However, the nature and frequency of complications following the harvesting of bone from the tibia in children is less clear. Apart from two earlier reports [2, 3], we were unable to locate studies that analysed donor site morbidity following the harvesting of large tibial grafts.

This prompted us to undertake this study in order to determine the frequency and nature of donor site complications following the harvesting of large cortical strut grafts from the tibial diaphysis in children.

Materials and methods

During the past 19 years (1990–2009), tibial cortical grafts were harvested from 47 children (27 boys and 20 girls). The most frequent indication for bone grafting was congenital pseudarthrosis of the tibia ($n = 42$); other indications included simple bone cyst ($n = 2$), aneurysmal bone cyst ($n = 1$), recurrent osteofibrous dysplasia of the tibia ($n = 1$) and non-union of the shaft of the femur ($n = 1$). On account of the nature of the disease, re-grafting was required in some children with pseudarthrosis of the tibia. In children who required repeat grafting, bone was

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harvested again from the original donor site in all instances. Grafts were harvested on three separate occasions in six children, twice in 18 children and once in 23 children; thus, a total of 77 bone graft harvesting procedures were performed on these 47 children.

Operative technique and post-operative management

The technique of harvesting graft was identical in all children. A pneumatic tourniquet was routinely used. A longitudinal incision was made on the shin extending from just distal to tibial tuberosity to a point just proximal to the distal tibial physis. The medial cortex was exposed subperiosteally and a long rectangular strut of cortical bone was harvested with the help of a power saw (Fig. 1a, b). The medullary contents were then scooped out and also preserved for grafting (Fig. 1c). The periosteal sleeve was closed meticulously with interrupted absorbable sutures (Fig. 1d) and the wound was closed over a suction drain placed outside the periosteum. A long leg cast was applied after releasing the tourniquet.

Post-operatively, the limb was kept elevated and intravenous opioid analgesia was administered during the first 48 h. The suction drain was removed after 48 h. The cast was removed after 6 weeks and unprotected weight-bearing was then permitted.

Data collection

The demographic information about each patient and specific information related to the surgery performed was collected from the case records. The operative time, estimated blood loss, the length of hospital stay, wound complications and post-operative pain were noted.

Forty children were examined at a mean of 5.5 years (range: 6 months–15.3 years) from the date of the last graft harvesting surgery. At the final follow-up, the status of the scar with reference to adherence to the tibia, hypertrophy or keloid formation, and altered sensation was noted. Deformities of the tibia, knee and ankle joints, if present, were noted and the range of motion of the knee and ankle joints were recorded. Bowing of the tibia in both planes and ankle valgus were measured on full-length radiographs taken at the final follow-up. The muscle power of all muscle groups in the leg was tested by manual muscle testing.

Results

Cortical graft was harvested from the right tibia in 21 children and from left side in 26. Non-vascularised fibula graft from the same limb was also harvested along with tibial strut graft in two instances. The mean age at the initial harvesting procedure was 3.96 years (range: 11 months–11 years). In children who required repeat grafting, the mean intervals between the first and second graft harvest, and between the second and third graft harvest were 2.5 years (range: 7 months–8.2 years) and 3.1 years (range: 1.8–4.7 years), respectively.

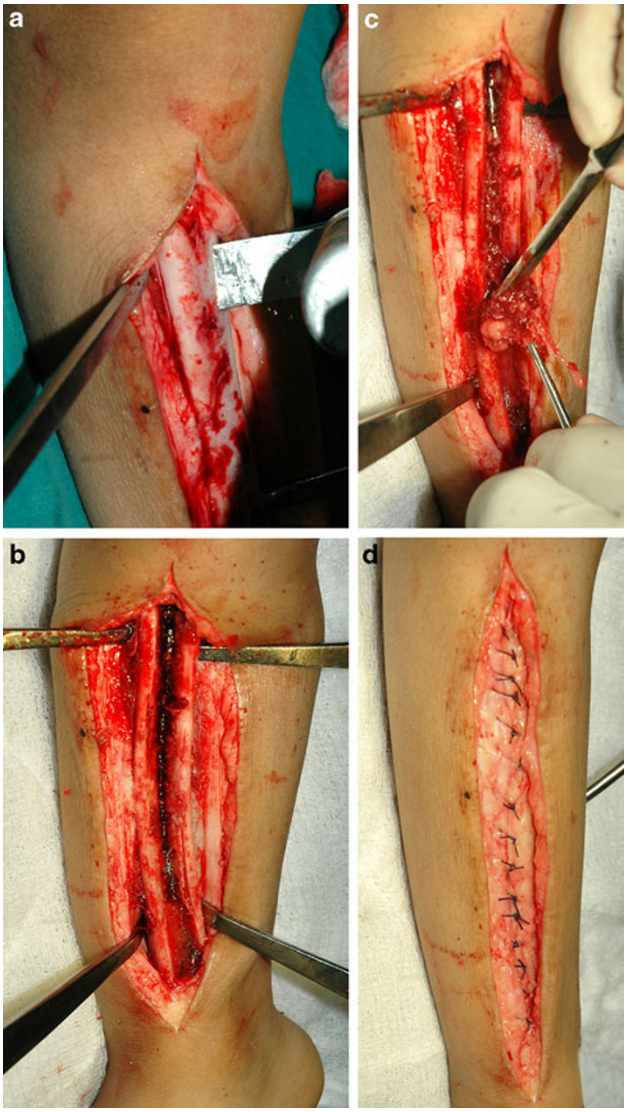

Fig. 1 The subcutaneous surface of the tibia is exposed subperiosteally (**a**) and a rectangular strut of cortical bone is harvested with the aid of a power saw (**b**). The medullary contents are scooped out and preserved for grafting (**c**). The periosteum is closed meticulously with interrupted absorbable sutures (**d**)

In children who underwent repeat grafting, it was noted that the tibial cortex at the original donor site had completely reconstituted at the time of re-harvesting (Fig. 2).

The mean tourniquet time was 60 min; the mean total blood loss (intra-operative and post-operative) was 57 ml (range: 10–175 ml). The duration of hospitalisation was

Fig. 2 The appearance of the tibial cortex in a child in whom graft had been harvested once 2 years earlier. There is no evidence of the old defect and the tibia has reconstituted completely. Fresh graft was harvested again from the same site

always determined by the status of the diseased limb and in no instance was longer hospitalisation required on account of problems with the donor limb. All of the incisions healed by primary intention. None of the patients had neurovascular complications and no child had post-operative pain for more than 3 weeks. All of the children were able to bear weight on the limb 6 weeks after surgery.

At final follow-up, none of the children had residual pain at the donor site; the scars were healthy (Fig. 3) and not adherent to the underlying tibia. All of the children had complete painless range of motion of the ankle and knee joints. There was no ankle deformity or instability in any of the patients. There was no demonstrable weakness of muscles of the leg. The radiographic evaluation at final follow-up showed that the defects in the cortex had healed with good cortico-medullary differentiation (Fig. 4). Mild anterior bowing of the anterior tibial cortex was noted in some children; the bowing tended to increase with repeat harvesting (5° ± 4° in children who had one graft harvested, 9° ± 4° in children who had graft harvested twice and 15° ± 6° in children who had graft harvested thrice).

There was no evidence of asymmetric growth of the proximal or distal tibial physes, as the proximal and distal tibial articular surfaces were normally inclined in all of the children. However, we were unable to determine if any symmetric growth stimulation or retardation occurred as the comparison of length with the contralateral tibia would not have been meaningful, since, in most instances, the contralateral tibia was pathological and often shorter than the donor tibia.

Fig. 3 The appearance of the scar of graft harvesting is seen on the right leg. The graft was used to treat congenital pseudarthrosis of the left tibia

Fig. 4 The radiological appearance of the tibia of a child who had cortical bone graft harvested 4 years previously

Fig. 5 A stress fracture of the tibia developed in this boy who had tibial graft harvested for the second time 10 months earlier (**a**). A segment of the fibula had also been removed as graft during the first operation. Union of the fracture was obtained after internal fixation with an intramedullary Rush rod (**b**)

Complications

One single major complication was encountered in this series; one child sustained a stress fracture of the shaft of the tibia. This 4-year-old child had a gap non-union of the left femur following osteomyelitis. Grafts were harvested from the right tibia and fibula and used to bridge the gap in the femur. The procedure failed and the bone graft was resorbed completely. Ten months later, a second grafting operation was undertaken and tibial cortical graft was harvested again from the right tibia. The child developed a stress fracture 10 months later (Fig. 5a). He was treated with open reduction and internal fixation with a Rush rod; sound union ensued (Fig. 5b).

Discussion

The study shows that donor site morbidity is very infrequent following the harvesting of large cortical grafts from the tibia in children. The fact that only one major complication which warranted surgical intervention was seen among 77 bone harvesting procedures bears this out. The solitary major complication (fracture) was in a child who had graft harvested from both the tibia and the fibula in the first instance. The fracture developed after a second tibial graft was harvested. We would now hesitate to harvest tibial graft from a child who has had a segment of the fibula also removed as graft. It is also possible that damage to the endosteal blood supply caused by curetting of the medullary cavity may have contributed to this complication.

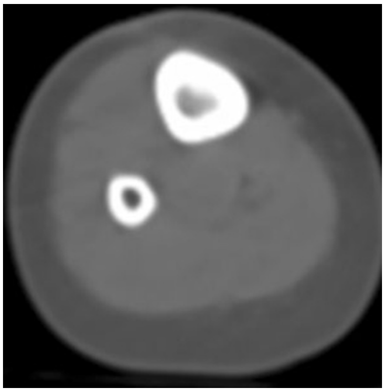

Fig. 6 Computed tomography (CT) scan of the leg of a boy who had tibial cortical graft harvested 8 weeks earlier shows that the cortex has completely reformed

Though we could not ascertain if harvesting of the graft affects the longitudinal growth of the tibia, there is evidence in the literature that, in some children, growth stimulation with consequent lengthening of a couple of centimetres can occur [2].

One of the remarkable features of tibial graft harvesting noted in the study was the complete regeneration of the harvested cortex. Meticulous closure of the periosteum is likely to have facilitated cortical regeneration. The reconstitution of the cortex appears to occur very rapidly, as demonstrated in one of the children who had a computed tomography (CT) scan performed 8 weeks after graft harvesting. The scan shows that the cortex of the tibia is completely reformed with no demonstrable defect and a normal medullary cavity (Fig. 6). The early regeneration of the cortex enabled us to re-harvest bone from the original site as early as 7 months after the initial harvesting. Re-harvesting tibial graft was not any more cumbersome than the original procedure and good quality cortical bone was obtained at the time of re-harvesting. We believe that this is a unique advantage of tibial bone grafting in the young child; regeneration of the cortex may not occur as readily in the older child. Though we have no experience with harvesting tibial graft from older children or young adults, we would probably advocate the technique of Judet and Patel [15], who elevate the periosteum along with a thin sliver of the cortex as a measure to improve the chances of reconstitution of the cortex.

Finally, the decision to opt for cortical graft rather than cancellous graft is governed by the characteristics of the graft best suited in the given clinical situation. Cortical graft would be preferred in situations where the graft is required to provide some mechanical support. Tibial cortical graft appears to provide sufficient strength for its use in the spine and other locations where it is subjected to compressive and torsional stresses [3–5, 16–18]. Recent reports of the use of cortical bone graft reamed out by an intra-medullary device suggest that morcellised cortical graft could also be used to fill cavities [19]. Thus, the indications for the use of tibial cortical graft may be wider than what we report in this study.

Our reason to opt for cortical graft in congenital pseudarthrosis of the tibia was because we felt that cortical bone would resist resorption better than cancellous bone and the results have been very gratifying.

Conclusion

We conclude that, in children who require bone grafting, if the mechanical or biological considerations dictate the preference for autogenous cortical bone graft, tibial bone grafting is an excellent option. Harvesting cortical bone graft from the tibia is simple and is fraught with negligible morbidity.

References

1. Albee F (1911) Transplantation of a portion of the tibia into the spine for Pott's disease: a preliminary report. JAMA 57:885–886
2. Zeller RD, Ghanem I, Miladi L, Dubousset J (1994) Posterior spinal fusion in neuromuscular scoliosis using a tibial strut graft. Results of a long-term follow-up. Spine 19:1628–1631
3. Yu WD, Bernstein RM, Watts HG (2003) Autogenous tibial strut grafts used in anterior spinal fusion for severe kyphosis and kyphoscoliosis. Spine 28:699–705
4. Barbieri CH, Mazzer N, Mazer MR (1999) Use of a delayed cortical bone graft to treat diaphyseal defects in the forearm. Int Orthop 23:295–301
5. Chen H, Qiu Y, Wang B, Yu Y, Zhu ZZ, Zhu LH (2005) Autogenous tibial strut grafts used in severe kyphoscoliosis: surgical policies and preliminary results. Chin Med J (Engl) 118:1245–1250
6. Vail TP, Urbaniak JR (1996) Donor-site morbidity with use of vascularized autogenous fibular grafts. J Bone Joint Surg Am 78:204–211
7. Babhulkar SS, Pande KC, Babhulkar S (1995) Ankle instability after fibular resection. J Bone Joint Surg Br 77:258–261
8. Pacelli LL, Gillard J, McLoughlin SW, Buehler MJ (2003) A biomechanical analysis of donor-site ankle instability following free fibular graft harvest. J Bone Joint Surg Am 85:597–603
9. Garrett A, Ducic Y, Athre RS, Motley T, Carpenter B (2006) Evaluation of fibula free flap donor site morbidity. Am J Otolaryngol 27:29–31
10. Banwart JC, Asher MA, Hassanein RS (1995) Iliac crest bone graft harvest donor site morbidity. A statistical evaluation. Spine 20:1055–1060
11. Arrington ED, Smith WJ, Chambers HG, Bucknell AL, Davino NA (1996) Complications of iliac crest bone graft harvesting. Clin Orthop Relat Res 329:300–309
12. Laurie SWS, Kaban LB, Mulliken JB, Murray JE (1984) Donor-site morbidity after harvesting rib and iliac bone. Plast Reconstr Surg 73:933–938
13. Ahlmann E, Patzakis M, Roidis N, Shepherd L, Holtom P (2002) Comparison of anterior and posterior iliac crest bone grafts in terms of harvest-site morbidity and functional outcomes. J Bone Joint Surg Am 84:716–720
14. Robertson PA, Wray AC (2001) Natural history of posterior iliac crest bone graft donation for spinal surgery: a prospective analysis of morbidity. Spine 26:1473–1476
15. Judet PR, Patel A (1972) Muscle pedicle bone grafting of long bones by osteoperiosteal decortication. Clin Orthop Relat Res 87:74–80
16. Malloy KM, Hilibrand AS (2002) Autograft versus allograft in degenerative cervical disease. Clin Orthop Relat Res 394:27–38
17. Hong Y, Sharma KM, Parks BG, Miller SD (2008) Biomechanical analysis of tibial strength after harvesting unicortical tibial grafts of two different lengths. Foot Ankle Int 29:726–729
18. Hong Y, Parks BG, Miller SD (2006) Biomechanical analysis of tibial strength after harvest of unicortical tibial grafts from two different sites. Foot Ankle Int 27:190–195
19. Belthur MV, Conway JD, Jindal G, Ranade A, Herzenberg JE (2008) Bone graft harvest using a new intramedullary system. Clin Orthop Relat Res 466:2973–2980