COMPARISON OF ANTERIOR AND POSTERIOR ILIAC CREST BONE GRAFTS IN TERMS OF HARVEST-SITE MORBIDITY AND FUNCTIONAL OUTCOMES

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Background: Previous studies have demonstrated high complication rates after harvest of iliac crest bone grafts. This study was undertaken to compare the morbidity related to the harvest of anterior iliac crest bone graft with that related to the harvest of posterior iliac crest bone graft and to determine differences in functional outcome.

Methods: The medical records of eighty-eight consecutive patients who had undergone a total of 108 iliac crest bone-grafting procedures for the treatment of chronic osteomyelitis from 1991 to 1998 were retrospectively reviewed. Demographic characteristics, the location of the harvest, the volume of bone graft that was harvested, the estimated blood loss, and postoperative complications were recorded. Fifty-eight patients completed a questionnaire pertaining to postoperative and residual pain, sensory disturbances, functional limitations, cosmetic appearance, and overall satisfaction with the bone-graft harvesting procedure.

Results: Sixty-six anterior and forty-two posterior bone-graft harvest sites were evaluated at a minimum of two years after the operation. A major complication was associated with 8% (five) of the sixty-six anterior sites and 2% (one) of the forty-two posterior sites. The rates of minor complications were 15% (ten) and 0%, respectively. In the series as a whole, there were ten minor complications (9%) and six major complications (6%). The rates of both minor complications ($p = 0.006$) and all complications ($p = 0.004$) were significantly higher after the anterior harvest procedures than they were after the posterior procedures. The postoperative pain at the donor site was significantly more severe ($p = 0.0016$) and of significantly greater duration ($p = 0.0017$) after the anterior harvests. No patient reported functional limitations at the latest follow-up evaluation.

Conclusions: In this series, the complication rate was lower than those previously reported by other investigators. Harvest of a posterior iliac crest bone graft was associated with a significantly lower risk of postoperative complications. On the basis of the results of this study, we recommend that iliac crest bone graft be harvested posteriorly whenever possible.

Harvesting of autogenous bone graft has been a common orthopaedic procedure for a long time. The iliac crest is the most common donor site because of easy access and procurement, low morbidity, and availability of large quantities of both cortical and cancellous bone. Despite some recent advances in bone-substitute technology, autogenous bone grafts remain the "gold standard" in reconstructive surgery because of their osteoinductive, osteoconductive, and non-immunogenic properties.

Several factors must be taken into consideration when choosing the donor site, including the location of the recipient bed, the quality and quantity of bone graft required, and the potential complications[1-6]. Harvesting of iliac crest bone graft is associated with some potentially serious complications. The most common symptoms attributable to the donor site are pain and sensory disturbances. Variations in patient population, diagnosis, procedure, surgical technique, and study design contribute to a broad range of reported complications related to iliac crest donor sites[1-16].

The purpose of our study was to compare the postoperative complications, the final outcomes, and the overall satisfaction rates in a homogeneous group of patients who had undergone harvest of either anterior or posterior iliac crest bone graft as part of a protocol to treat chronic osteomyelitis in an extremity. We wanted to identify problems associated with surgical technique that would further decrease morbidity

associated with harvest of iliac crest bone graft.

Materials and Methods

The medical records and charts of the latest clinic visit of eighty-eight patients who had undergone a total of 108 iliac crest bone-graft harvest procedures as part of a limb-salvage protocol for the treatment of chronic osteomyelitis from 1991 to 1998 were retrospectively reviewed. Patient demographics, the location of the harvest site, the volume of bone graft that was harvested, the estimated blood loss, and minor and major complications were recorded. Minor complications were defined as self-limited events that did not require an additional surgical procedure; responded to nonoperative management, such as aspiration of a hematoma or use of additional pain medications; and did not cause any permanent disability. Major complications were those that led to prolonged hospitalization, required additional surgery, or caused substantial disability. Pain and sensory loss were defined as temporary when they persisted for less than six months and as residual when they persisted for at least six months. Residual pain and sensory loss were considered major complications. Questions regarding all complications were routinely asked, and the answers were recorded in the clinic chart of every patient. No patient had more than one complication in our series.

All harvesting procedures were performed by one surgeon (M.P.). While the primary surgeon focused on the graft-harvesting procedure, another group of plastic surgeons elevated a muscle flap that had been previously transferred to the recipient site to cover the osseous defect. After completion of both procedures, the primary surgeon performed the final reconstruction of the limb defect with use of the previously harvested bone-graft chips. The site for the bone-graft harvest was not chosen according to specific criteria but was selected on the basis of the location of the recipient site, the positioning of the patient at the surgery, and whether there were previous harvest sites. Seventy-two (82%) of the patients underwent one iliac crest harvesting procedure; twelve (14%), two procedures; and four (5%), three procedures.

The anterior and posterior harvesting procedures were performed in a standardized fashion. To harvest the anterior bone grafts, a slightly curved incision lateral to the iliac wing was made 2 cm dorsal to the anterior superior iliac spine in order to avoid injuring the lateral femoral cutaneous nerve. To harvest the posterior bone grafts, an almost vertical incision was made over and slightly lateral to the posterior iliac spine and parallel to the route of the superior cluneal nerves. Tricortical grafts were not used. Both the anterior and posterior grafts were in the form of bone chips and strips. The "outer table" technique was employed at both harvest sites: both iliac crests were exposed subperiosteally, the outer cortical table was removed with use of osteotomes, and cancellous strips of bone were taken from the outer table of the ilium with gouges and curets. All of the bone-graft strips were then converted to chips with use of bone-nibblers or rongeurs. The grafts were placed in a 2-oz (59-mL) medicine glass and covered with marrow blood; their volume was measured with the use of the volumetric part of a syringe. All donor-site incisions were closed over Jackson-Pratt drains, which were left in place for three days postoperatively. The amount of blood loss, including the intraoperative blood loss and the drain output over the three days, was measured.

A detailed functional outcome questionnaire pertaining to the level and duration of postoperative pain, residual pain, sensory disturbances, functional limitations, cosmetic appearance, and overall satisfaction with the result of the bone-graft procedure were mailed to all participants of this study. The questionnaire asked the patient to grade the severity of postoperative pain retrospectively on a scale of 1 to 10, with 1 corresponding to minimal pain and 10, to very severe pain. There were specific questions concerning the locations of sensory disturbances, both temporary and residual. Functional disturbances were evaluated with questions pertaining to gait, difficulty with climbing stairs, and difficulty with rising from a seated position. Patients were also asked whether they were "very satisfied," "satisfied," "somewhat satisfied," "somewhat dissatisfied," "dissatisfied," or "very dissatisfied" with the cosmetic appearance of the scar and with the overall result of the bone-graft procedure.

Fifty-eight (66%) of the eighty-eight patients, who had undergone a total of seventy-four harvest procedures, responded to the questionnaire. These patients were interviewed by telephone or at their latest follow-up clinic visit by one of us (E.A.) who was not involved in patient care in order to avoid any patient bias toward the treating surgeon. When responses to the questionnaire were ambiguous, a telephone call was made for clarification or verification.

Statistical Analysis

Statistical analysis was performed with the Mann-Whitney U test with use of the two independent sample test, the Pearson chi-square test, and the Fisher exact test. Any value of $p < 0.05$ was considered significant.

Results

Of the eighty-eight patients in this study, seventy-five were men and thirteen were women. The average age was 46.2 years (range, twelve to seventy-seven years). All patients were being treated for chronic osteomyelitis. Sixty-three of the patients had involvement of the tibia; twenty-two, the femur; two, the humerus; and one, the ulna. All patients received intravenous antibiotics for five days while awaiting the results of cultures of specimens taken from the infected bone site.

The results of sixty-six anterior and forty-two posterior iliac crest bone-graft harvest procedures were evaluated at a minimum of two years and an average of five years after the operation. Ten minor complications (9%) and six major complications (6%) occurred overall. The rates of major and minor complications were 8% (five of sixty-six) and 15% (ten of sixty-six), respectively, in association with the anterior donor sites and 2% (one of forty-two) and 0%, respectively, in association with the posterior donor sites (Table I). The rates of minor complications ($p = 0.006$) and all complications ($p =$

0.004) were significantly higher in association with the anterior sites, but, with the numbers available, no difference between the anterior and posterior sites was noted with regard to major complications ($p = 0.401$).

Of the five major complications associated with the anterior bone-graft donor sites, three consisted of numbness over the distribution of the lateral femoral cutaneous nerve that persisted for more than six months. In addition, an abdominal hernia caused by muscle insufficiency developed eight months after a right anterior bone-graft procedure in a sixty-eight-year-old man. A previously harvested ipsilateral rectus abdominis muscle flap may or may not have contributed to this complication. Finally, one patient reported residual pain lasting for more than six months after an anterior procedure.

Ten minor complications, including two superficial hematomas, five temporary sensory disturbances, and three cases of mild pain over the wound area lasting between two weeks and four months, occurred after the anterior harvest procedures. All sensory disturbances developed immediately postoperatively, and all of these disturbances as well as all mild pain resolved by six months postoperatively. Of the two hematomas, one was evacuated postoperatively through the surgical drain and the other resolved spontaneously. No reoperations were required.

Only one major complication, consisting of residual numbness over the donor site lasting for more than six months, occurred after a posterior harvest procedure. No minor complications were observed after these procedures.

On the average, 54.53 cm^3 of bone had been harvested from the anterior sites and 55.12 cm^3, from the posterior sites. The mean intraoperative blood loss was 75 mL in both groups. The mean total blood loss (intraoperative blood loss and drain output) was 232.47 mL for the patients with an anterior procedure and 169.14 mL for those with a posterior procedure. This difference between the two groups was significant (Mann-Whitney U test, $p = 0.018$).

Of the fifty-eight patients who responded to the functional outcome questionnaire, those who had undergone an anterior harvest (forty-six procedures) had more severe postoperative pain ($p = 0.0016$) and had pain for a longer period of time ($p = 0.0017$) than did those who had undergone a posterior harvest (twenty-eight procedures). All but one patient reported satisfaction with the result of the bone graft procedure as related to donor-site complications. With the numbers available, no differences between the two groups were reported with regard to satisfaction with the cosmetic appearance or with overall satisfaction. All but one of the eleven patients who had had bone-graft harvest at multiple sites and had responded to the questionnaire were very satisfied with the result of the procedure overall. One patient was simply satisfied and had experienced persistent numbness at both donor sites postoperatively.

TABLE I Comparison of Blood Loss, Graft Volume, and Complication Rates Between the Two Harvest Sites

	Harvest Site	
	Anterior (N = 66)	Posterior (N = 42)
Mean total blood loss *(mL)*	232.47	169.14
Mean graft volume *(cm^3)*	54.53	55.12
Complication*		
Hematoma	3% (2)	0
Temporary sensory disturbance	8% (5)	0
Residual sensory disturbance	5% (3)	2% (1)
Temporary pain	5% (3)	0
Residual pain	2% (1)	0
Minor complication	15% (10)	0
Major complication	8% (5)	2% (1)
Complications overall	23% (15/66)	2% (1/42)

*The values are given as the percentage, with the number of sites in parentheses.

Discussion

The reported overall prevalence of complications following anterior and posterior iliac crest bone-grafting procedures has varied[1-6]. Higher rates have been reported in association with reconstructive spine surgery[6,10,16-23]. Documented donor-site complications include hematoma, seroma, false aneurysm, nerve and arterial injuries, gait disturbances, fracture of the iliac wing, visceral and ureteral injuries, peritoneal perforation, infection, sacroiliac instability, pain, and growth disturbance in children[1-16]. Distinctions between major and minor and acute and chronic complications have varied among series[1-6,9-13]. Major complications have been reported[1-6] to be less common (rates ranging from 0.7% to 25%) than minor ones (rates ranging from 9.4% to 24%). Harvest of iliac crest bone grafts for use in the spine has been associated with rates of major complications ranging from 2.8% to 10% and rates of minor complications ranging from 5.6% to 39%[10,22]. With criteria similar to those used in our study, rates of major complications have ranged from 1.2% to 21.5% and rates of minor complications have ranged from 1.8% to 15.4% for harvest of grafts for use in areas other than the spine[5,11]. Younger and Chapman[1] reported rates of major and minor complications of 5.3% and 25% at anterior iliac crest donor sites and 11.3% and 18.4% at posterior sites. However, they stated that "some patients had more than one related complication but only the most significant one was counted for statistical purposes." In our series, all complications were recorded but no patient had more than one complication. We used the definition of major and minor complications provided by Younger and Chapman.

Variation in the position of the lateral femoral cutaneous nerve is a contributing factor associated with injury of that nerve[24-30]. Ghent[28] and recently Murata et al.[30] identified four anatomical patterns of the lateral femoral cutaneous nerve. Because of these variations, the nerve is at risk for in-

jury during the harvesting procedures[24-30]. In our study, there were three residual sensory disturbances that were attributed to injury of the lateral femoral cutaneous nerve. This rate is lower than reported rates in the literature, which have ranged from 8.3% to 37% following anterior procedures[1-6,21,31].

Technical modifications to overcome the problem of pain at the wound site[2-6,18,21,23] include the use of anesthetic regimens[32], a pneumatic gouge to harvest the bone[33], minimally invasive tools[34], vertical or oblique skin incisions to avoid cutting cutaneous nerves, incisions ≥3 cm dorsal to the anterior superior iliac spine, subperiosteal dissection with careful hemostasis, and a unicortical cancellous graft harvest technique[6,19,33,35-37]. In our study, there was a difference in pain between the groups treated with anterior and posterior harvest procedures. Three patients had temporary pain and one patient had residual pain after an anterior harvest, but no patient had temporary or residual pain after a posterior procedure.

Reported rates of donor-site infection have ranged from 0% to 3% in contemporary series[7,22,38]. The absence of postoperative infections in our study may be attributed to the fact that all patients were receiving intravenous antibiotics for treatment of the infection at the time of the bone-graft harvest. Hematoma formation has been reported in 1% to 10% of patients following harvesting of iliac crest bone grafts, and it has been associated with an increased risk for infection[22,39,40]. The decreased postoperative blood loss when the graft had been obtained from the posterior iliac crest in our series may have been due to the hemostatic effect of the patient lying supine, as suggested by Mirovsky and Neuwirth[19,27]. In our series, there were only two superficial hematomas and neither required treatment. We think that this low prevalence was at least in part due to good exposure and meticulous hemostasis intraoperatively and to the use of a drain for three days postoperatively.

Although to our knowledge no one has specifically studied complications related to the size of the graft, some evidence suggests that the larger the graft harvested, the higher the rate of major complications[6-8,10,41]. The average volume of bone graft harvested from anterior and posterior sites has been reported to be 13 and 30 cm^3, respectively[3,11,19]. In our study, a relatively large amount of corticocancellous or cancellous bone graft, averaging >50 cm^3, was obtained. Despite the large volumes, the prevalence of complications was low.

The rates of satisfaction after harvest of iliac crest bone graft has ranged between 83% and 88% when a posterior donor site was used[31] and between 82% and 86.1% when an anterior site was used[11,22]. In our study, all of the patients except one (98%) reported satisfaction with regard to the cosmetic appearance of the wound and the result of the graft procedure overall.

In this series, the complication rate was lower than has been previously reported by other investigators[1-6,10,16,18-23]. Posterior harvesting of iliac crest bone graft was associated with a significantly decreased risk of postoperative complications. In light of the results of this study, it seems that the complication rate, especially the risk of nerve injury and subsequent numbness, is greater with the anterior harvesting procedure. On the basis of the results of this study, we recommend posterior harvesting of iliac crest bone graft whenever possible. ■

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References

1. **Younger EM, Chapman MW.** Morbidity at bone graft donor sites. *J Orthop Trauma.* 1989;3:192-5.
2. **Fowler BL, Dall BE, Rowe DE.** Complications associated with harvesting autogenous iliac bone graft. *Am J Orthop.* 1995;24:895-903.
3. **Arrington ED, Smith WJ, Chambers HG, Bucknell AL, Davino NA.** Complications of iliac crest bone graft harvesting. *Clin Orthop.* 1996;329:300-9.
4. **Goulet JA, Senunas LE, DeSilva GL, Greenfield ML.** Autogenous iliac crest bone graft. Complications and functional assessment. *Clin Orthop.* 1997; 339:76-81.
5. **Keller EE, Triplett WW.** Iliac bone graft: review of 160 consecutive cases. *J Oral Maxillofac Surg.* 1987;45:11-4.
6. **Kurz LT, Garfin SR, Booth RE Jr.** Harvesting autogenous iliac bone grafts. A review of complications and techniques. *Spine.* 1989;14:1324-31.
7. **Lim EV, Lavadia WT, Roberts JM.** Superior gluteal artery injury during iliac bone grafting for spinal fusion. A case report and literature review. *Spine.* 1996;21:2376-8.
8. **Stevens KJ, Banns M.** Sciatic nerve palsy caused by haematoma from iliac bone graft donor site. *Eur Spine J.* 1994;3:291-3.
9. **Wippermann BW, Schratt HE, Steeg S, Tscherne H.** [Complications of spongiosa harvesting of the ilial crest. A retrospective analysis of 1,191 cases]. *Chirurg.* 1997;68:1286-91. German.
10. **Banwart JC, Asher MA, Hassanein RS.** Iliac crest bone graft harvest donor site morbidity. A statistical evaluation. *Spine.* 1995;20:1055-60.
11. **Kalk WW, Raghoebar GM, Jansma J, Boering G.** Morbidity from iliac crest bone harvesting. *J Oral Maxillofac Surg.* 1996;54:1424-9; discussion 1430.
12. **Laurie SW, Kaban LB, Mulliken JB, Murray JE.** Donor-site morbidity after harvesting rib and iliac bone. *Plast Reconstr Surg.* 1984;73:933-8.
13. **Moss AL.** The morbidity of harvesting bone from the iliac crest. *Cleft Palate Craniofac J.* 2000;37:326.
14. **Porchet F, Jaques B.** Unusual complications at iliac crest bone graft donor site: experience with two cases. *Neurosurgery.* 1996;39:856-9.
15. **Rossillon R, Desmette D, Rombouts JJ.** Growth disturbance of the ilium after splitting the iliac apophysis and iliac crest bone harvesting in children: a retrospective study at the end of growth following unilateral Salter innominate osteotomy in 21 children. *Acta Orthop Belg.* 1999;65:295-301.
16. **Skaggs DL, Samuelson MA, Hale JM, Kay RM, Tolo VT.** Complications of posterior iliac crest bone grafting in spine surgery in children. *Spine.* 2000;25:2400-2.

17. **Shin AY, Moran ME, Wenger DR.** Superior gluteal artery injury secondary to posterior iliac crest bone graft harvesting. A surgical technique to control hemorrhage. *Spine.* 1996;21:1371-4.

18. **Frymoyer JW, Hanley E, Howe J, Kuhlmann D, Matteri R.** Disc excision and spine fusion in the management of lumbar disc disease. A minimum ten-year followup. *Spine.* 1978;3:1-6.

19. **Mirovsky Y, Neuwirth MG.** Comparison between the outer table and intracortical methods of obtaining autogenous bone graft from the iliac crest. *Spine.* 2000;25:1722-5.

20. **Moed BR, Thorderson N, Linden MD.** Reharvest of iliac crest donor site cancellous bone. *Clin Orthop.* 1998;346:223-7.

21. **Fernyhough JC, Schimandle JJ, Weigel MC, Edwards CC, Levine AM.** Chronic donor site pain complicating bone graft harvesting from the posterior iliac crest for spinal fusion. *Spine.* 1992;17:1474-80.

22. **Schnee CL, Freese A, Weil RJ, Marcotte PJ.** Analysis of harvest morbidity and radiographic outcome using autograft for anterior cervical fusion. *Spine.* 1997;22:2222-7.

23. **Summers BN, Eisenstein SM.** Donor site pain from the ilium. A complication of lumbar spine fusion. *J Bone Joint Surg Br.* 1989;71:677-80.

24. **Aszmann OC, Dellon ES, Dellon AL.** Anatomical course of the lateral femoral cutaneous nerve and its susceptibility to compression and injury. *Plast Reconstr Surg.* 1997;100:600-4.

25. **de Ridder VA, de Lange S, Popta JV.** Anatomical variations of the lateral femoral cutaneous nerve and the consequences for surgery. *J Orthop Trauma.* 1999;13:207-11.

26. **Ebraheim NA, Yang H, Lu J, Biyani A, Yeasting RA.** Anterior iliac crest bone graft. Anatomic considerations. *Spine.* 1997;22:847-9.

27. **Mirovsky Y, Neuwirth M.** Injuries to the lateral femoral cutaneous nerve during spine surgery. *Spine.* 2000;25:1266-9.

28. **Ghent WR.** Further studies on meralgia paresthetica. *CMAJ.* 1961;85:871-5.

29. **van den Broecke DG, Schuurman AH, Borg ED, Kon M.** Neurotmesis of the lateral femoral cutaneous nerve when coring for iliac crest bone grafts. *Plast Reconstr Surg.* 1998;102:1163-6.

30. **Murata Y, Takahashi K, Yamagata M, Shimada Y, Moriya H.** The anatomy of the lateral femoral cutaneous nerve, with special reference to the harvesting of iliac bone graft. *J Bone Joint Surg Am.* 2000;82:746-7.

31. **Colterjohn NR, Bednar DA.** Procurement of bone graft from the iliac crest. An operative approach with decreased morbidity. *J Bone Joint Surg Am.* 1997;79:756-9.

32. **Puri R, Moskovich R, Gusmorino P, Shott S.** Bupivacaine for postoperative pain relief at the iliac crest bone graft harvest site. *Am J Orthop.* 2000;29:443-6.

33. **Duncan RW, McGuire RA, Meydrech EF.** Pneumatic gouge versus standard method for iliac crest harvesting. *Orthop Rev.* 1994;23:672-5.

34. **Steffen T, Downer P, Steiner B, Hehli M, Aebi M.** Minimally invasive bone harvesting tools. *Eur Spine J.* 2000;9 Suppl 1:S114-8.

35. **Burstein FD, Simms C, Cohen SR, Work F, Paschal M.** Iliac crest bone graft harvesting techniques: a comparison. *Plast Reconstr Surg.* 2000;105:34-9.

36. **Tanishima T, Yoshimasu N, Ogai M.** A technique for prevention of donor site pain associated with harvesting iliac bone grafts. *Surg Neurol.* 1995;44:131-2.

37. **Tayapongsak P, Wimsatt JA, LaBanc JP, Dolwick MF.** Morbidity from anterior ilium bone harvest. A comparative study of lateral versus medial surgical approach. *Oral Surg Oral Med Oral Pathol.* 1994;78:296-300.

38. **Rudman RA.** Prospective evaluation of morbidity associated with iliac crest harvest for alveolar cleft grafting. *J Oral Maxillofac Surg.* 1997;55:219-23; discussion 223-4.

39. **Hutchinson MR, Dall BE.** Midline fascial splitting approach to the iliac crest for bone graft. A new approach. *Spine.* 1994;19:62-6.

40. **Wilson PA.** Pain relief following iliac crest bone harvesting. *Br J Oral Maxillofac Surg.* 1995;33:242-3.

41. **Caminiti MF, Sandor GK, Carmichael RP.** Quantification of bone harvested from the iliac crest using a power-driven trephine. *J Oral Maxillofac Surg.* 1999;57:801-5; discussion 805-6.