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A retrospective study of iliac crest bone grafting techniques with allograft reconstruction: do patients even know which iliac crest was harvested?

Clinical article

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Object. Considerable biological research has been performed to aid bone healing in conjunction with lumbar fusion surgery. Iliac crest autograft is often considered the gold standard because it has the vital properties of being osteoconductive, osteoinductive, and osteogenic. However, graft site pain has been widely reported as the most common donor site morbidity. Autograft site pain has led many companies to develop an abundance of bone graft extenders, which have limited proof of efficacy. During the surgical consent process, many patients ask surgeons to avoid harvesting autograft because of the reported pain complications. The authors sought to study postoperative graft site pain by simply asking patients whether they knew which iliac crest was grafted when a single skin incision was made for the fusion operation.

Methods. Twenty-five patients underwent iliac crest autografting with allograft reconstruction during instrumented lumbar fusion surgery. In all patients the autograft was harvested through the same skin incision but with a separate fascial incision. At various points postoperatively, the patients were asked if they could tell which iliac crest had been harvested, and if so, how much pain did it cause (10-point Numeric Rating Scale).

Results. Most patients (64%) could not correctly determine which iliac crest had been harvested. Of the 9 patients who correctly identified the side of the autograft, 7 were only able to guess. The 2 patients who confidently identified the side of grafting had no pain at rest and mild pain with activity. One patient who incorrectly guessed the side of autografting did have significant sacroiliac joint degenerative pain bilaterally.

Conclusions. Results of this study indicate the inability of patients to clearly define their graft site after iliac crest autograft harvest with allograft reconstruction of the bony defect unless they have a separate skin incision. This simple, easily reproducible pilot study can be expanded into a larger, multiinstitutional investigation to provide more definitive answers regarding the ideal, safe, and cost-effective bone graft material to be used in spinal fusions.
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Key Words • **iliac crest bone graft** • **autograft** • **lumbar fusion** • **spinal arthrodesis** • **bony extender** • **technique**

Iliac crest autograft has long been considered the gold standard to help heal a posterior lumbar arthrodesis. Though not necessary in all cases, the bone graft is used to extend the amount of locally harvested bone and has the vital properties of being osteoconductive, osteoinductive, and osteogenic. One problem with iliac crest autograft is the widely reported complication rate, with donor site pain being the most frequent complication.[5,11] Because of donor site morbidity, spine surgeons have increasingly used synthetic and recombinant bone graft extenders, and an entire industry has arisen from this market, with sales exceeding $1.6 billion per year in the United States.[14] The severity of posterior iliac crest donor site morbidity has long been debated, with several publications reporting that the problem may be overstated or that long-term morbidity is no different from that in patients who did not have autografting.[19,20,22] Despite the various reports in the literature, many patients specifically request that their surgeons avoid harvesting an iliac crest autograft given their fears of graft site morbidity. We performed a simple, easily replicated study in which we harvested iliac crest bone graft from a separate muscle fascial incision but within the same midline skin incision during posterior spinal fusion surgery. The bony defects at the harvest site were reconstructed with cortico-cancellous allograft bone. After surgery we asked

Abbreviation used in this paper: NRS = Numeric Rating Scale.

the patients if they could tell us which iliac crest had been harvested. Our premise was that if donor site morbidity were significant, then the patients would be able to indicate which side had been harvested without being told. If they were unable to tell which side had been harvested, then it is possible that iliac crest donor site morbidity is not as significant as it is currently thought to be.

Methods

Study Enrollment

The institutional review board at the Mayo Clinic in Jacksonville, Florida, approved this study as a pilot study with limited enrollment even though all performed procedures were within the surgeons' scope of practice. During their preoperative appointments, the patients who had consented to participate in the study agreed to be blinded to the side of the iliac crest that would be harvested. As part of the informed consent process, the patients were offered several grafting options, including local morselized autograft alone, various synthetic bony extenders, allograft, and iliac crest autograft. They were also made aware that they would be asked at a later date which side they thought the autograft had been harvested from.

Patients were suitable candidates for this study if they were planning to undergo a posterior instrumented spinal fusion involving the lumbar spine with iliac crest autografting. They had to agree to be blinded to the side of autograft harvesting as well as to accept allograft reconstruction of the defect, which is our current procedure of choice in patients with iliac crest autografting.

Exclusion criteria included previous iliac crest harvest, refusal of iliac crest autografting, and a diagnosis of osteoporosis.

If patients preferred to have a certain side harvested, then we complied with their request, and they were not enrolled in the study. Only one patient refused allograft reconstruction and was not enrolled in the study. If anatomy at the time of surgery did not allow for an efficient iliac crest harvest through the same skin incision, then a separate skin incision was made, and the patient was removed from the study. Allied staff told one patient the side of his iliac crest harvesting on postoperative Day 1, so the patient was removed from the study. One patient reviewed her operative report just prior to her clinic appointment, so she was removed from the study. Twenty-five enrolled patients completed the study.

Surgical Technique

Iliac crest bone graft was harvested when clinically indicated to extend the amount of local autograft bone when performing posterior lumbosacral fusion surgery. The exact amount harvested was not consistently reported and was not intended as a variable in this study. Nonetheless, the average amount of bone harvested from each case is estimated to be 30 cm^3.

In all but two cases, the surgery involved a traditional midline skin incision and subperiosteal muscle dissection to expose the spine. At some point in the surgery, the deep retractors were removed, and a plane was dissected between Scarpa's fascia layer and the muscle fascia layer until the posterior superior iliac spine was encountered. The intraoperative left-versus-right decision was not randomized nor based on any patient factors. A separate muscle fascia incision was made and cortico-cancellous iliac crest bone graft was harvested in a standard fashion by using a series of osteotomes and gouges. After an adequate amount of bone was collected, the defect was irrigated with antibiotic-impregnated solution, then the bony defect was reconstructed by snugly packing cortico-cancellous allograft bone. The surgeons erred on the side of overfilling rather than under-filling the bony defects with the expectation that the bone would condense and remodel the patient's natural contour (Figs. 1–3). The new muscle fascia incision was then immediately closed, as was the dissection tract, after further antibiotic irrigation.

In two cases, the surgery involved a minimally invasive paramedian muscle splitting approach to the spine. In these cases, the skin incisions for the percutaneous screws and tubular dilators were connected to give a single paraspinous skin incision on either side, which is our typical approach in such cases (rather than multiple small incisions in a line). At some point in the surgery, the tubular dilator was directed toward the iliac crest, and a separate muscle fascia incision was made to provide access to the iliac crest. Bone was harvested and reconstructed in a fashion similar to that described above.

Follow-Up

The patients who agreed to participate in the study were asked at routine postoperative follow-up appointments if they knew which iliac crest had been harvested, how confident they were with their answer (or if they had to guess), and to rate the amount of pain in their iliac crest and back according to the Numeric Rating Scale (NRS) on a scale of 1–10.[15] If the question was not asked

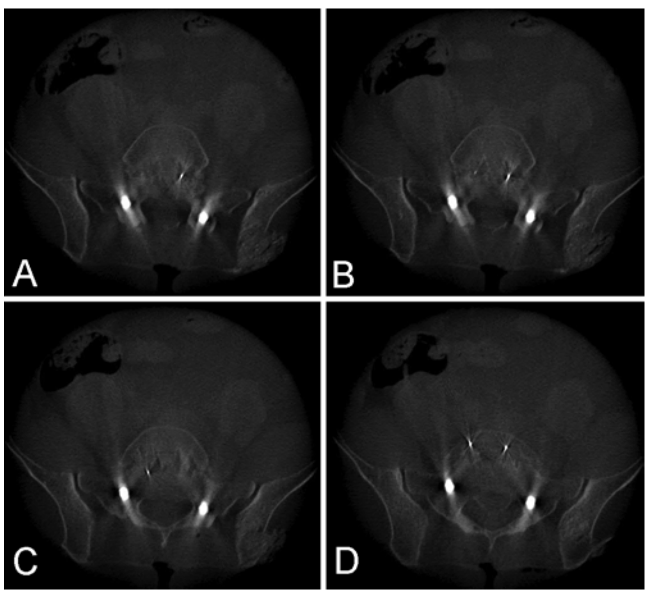

Fig. 1. Intraoperative axial images obtained with cone beam CT. Sequential images reveal the iliac crest defect on the patient's left side, which was reconstructed with cortico-cancellous allograft. Note the allograft extending beyond the confines of the native iliac crest margins.

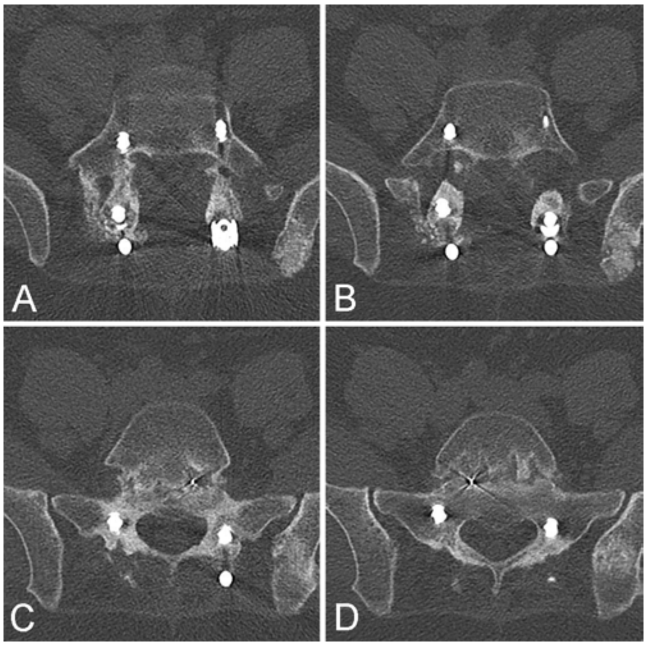

Fig. 2. Axial CT images from the same patient mentioned in Fig. 1, which were obtained 6 months postoperatively. Sequential images show that the left iliac crest harvesting site and reconstruction has remodeled to more closely replicate the native contours of the bone. Note that the extraosseous allograft has been resorbed.

in the clinic, a follow-up phone call was made. We purposely chose to vary follow-up times because we wanted to obtain both short- and relatively long-term outcomes. The study questions could only be reliably asked once. We used either the operative reports or postoperative CT scans to determine which side was harvested and whether the patients' answers were correct.

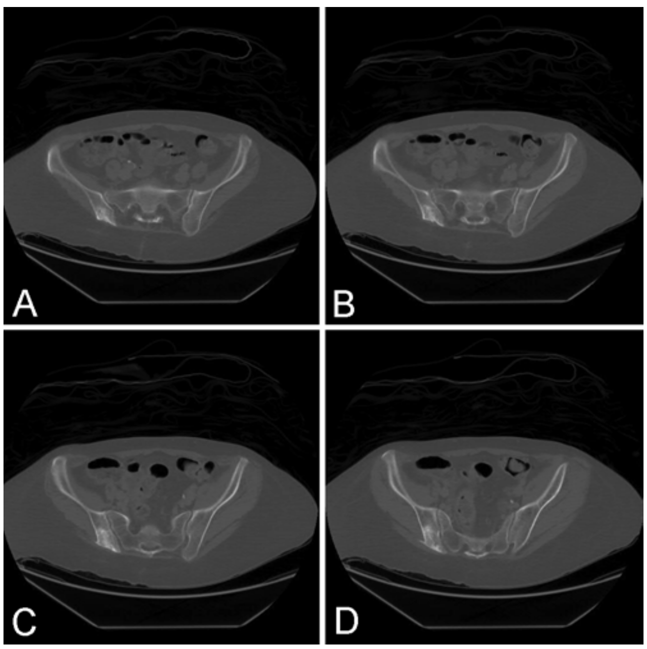

Fig. 3. Axial CT images obtained in a different patient at 18 months postoperatively. Note that the bony remodeling and contouring closely replicate the native state.

Statistical Methods

A retrospective statistical analysis of the data was performed using a simple one-proportion Z-test. The sum of all patients who correctly identified or guessed which iliac crest had been used for harvesting was divided by the total number of patients in the study. This proportion was tested against 0.5: the expected probability that patients would by chance guess correctly which iliac crest (right or left) had been used. A p value was produced from this test, and significance was set at $p < 0.05$.

Results

Demographic information for the study participants is displayed in Table 1. Of the 25 patients, 10 were male. The postoperative follow-up varied from 1 to 22 months (mean 8.3 months). All patients underwent posterior lumbar instrumented arthrodesis with pedicle screw fixation. Four patients underwent surgery for spinal deformity correction. One patient underwent L-4 vertebrectomy for removal of a phosphaturic mesenchymal tumor. Iliac crest bone grafting was performed during the posterior reconstruction portion of this case. All other surgeries were performed for degenerative conditions of the lumbar spine. Thirteen patients had autograft taken from their right iliac crest, and 12 had autograft taken from the left. Tables 2 and 3 display additional pertinent data for this study.

Nine (36%) of the 25 patients correctly identified the side of iliac crest autografting, which is not statistically significant ($p = 0.11$). Among these 9 patients, 7 admitted guessing and only 2 patients were confident in their answers. One of the two confident answers came from a patient reporting a pain level of 4 when active, based on the 10-point NRS; the other confident answer came from a patient reporting a pain level of 3. Both patients reported 0/10 pain at rest. This indicates an 8% (2 of 25 patients) perceived rate of pain after iliac crest harvesting. One patient who answered correctly had mild intermittent pain rated as 3 with activity, but the pain occurred rarely, and

TABLE 1: Summary of demographic information in 25 patients who underwent iliac crest bone grafting

Parameter	No. (%)
sex	
male	10 (40)
female	15 (60)
surgical indication	
degenerative disorders	20 (80)
spinal deformity	4 (16)
tumor	1 (4)
side of autograft	
rt	13 (52)
lt	12 (48)
time of follow-up questioning in mos	
range	1–22
mean	8.3

TABLE 2: Iliac crest autograft data for 25 patients

Case No.	No. of Fusion Levels; Indication for Surgery	Follow-Up Time When Questions Asked (mos)	NRS Score for Iliac Crest Pain	Correct Answer?; Guess or Confident Answer?
1	4; coronal deformity	22	0	no; unable to guess
2	1; degeneration	3	0	no; guess
3	8; coronal deformity	20	8*	no; guess
4	1; degeneration	17	0	yes; guess
5	4; degeneration	16	0	no; guess
6	4; tumor	19	0	no; unable to guess
7	2; degeneration	16	0	no; unable to guess
8	2; degeneration	11	0†	yes; confident
9	2; degeneration	6	0	yes; guess
10	1; degeneration	6	0	no; guess
11	2; degeneration	10	0	yes; guess
12	4; degeneration	9	0	yes; guess
13	3; degeneration	8	0	no; guess
14	1; degeneration	7	0	no; guess
15	1; degeneration	3	3	yes; confident
16	2; degeneration	2	0	no; guess
17	3; degeneration	5	0	no; unable to guess
18	2; degeneration	5	0	no; guess
19	3; degeneration	2	0‡	no; guess
20	14; deformity	7	0	no; unable to guess
21	2; degeneration	2	0	yes; guess
22	4; coronal deformity	2	0	yes; guess
23	4; degeneration	1	0§	yes; guess due to mild intermittent pain
24	2; degeneration	6	0	no; guess
25	2; degeneration	3	0	no; guess
mean	3.1	8.3	0.6¶	

* Bilateral sacroiliac joint pain diagnosed with focused exam and injections.
† While at rest, but 4 "only when pushing it."
‡ Has right hip bursa pain diagnosed by orthopedic surgeon.
§ At rest; occasionally 3 with activity.
¶ With activity.

he had trouble distinguishing whether the pain was felt in his back or over his iliac crest. When queried, the patient said he could not answer without guessing, although he did guess correctly. One patient who guessed incorrectly did report 8/10 pain on the NRS bilaterally and has been diagnosed with pain related to sacroiliac joint degeneration after markedly positive findings on a focused clinical examination and percutaneous injections into the joints. If we include these 2 patients in the group with pain due to iliac crest harvest, the perceived rate would increase to 16% (4 of 25 patients).

Periprocedural complications were noted in 4 patients (16%), but none were attributable to the iliac crest harvesting. One patient (4%) developed a deep wound infection that required operative irrigation and debridement. Risk factors for infection in this patient included diabetes, morbid obesity, renal failure, and chronic corticosteroid dependence. Two patients (8%) had unintended durotomies that were repaired without further complication. One patient (4%) had transient postoperative left upper-extremity weakness, which was presumably attributable to ulnar neuropathy caused by intraoperative positioning.

Discussion

Iliac crest bone grafting has traditionally helped spine surgeons extend the amount of bone used to help heal a spinal arthrodesis.[17,25,27] This procedure has well-documented complications, most commonly chronic graft site pain.[1,5,11,16] The other reported complications include prolonged surgery time, increased blood loss, longer hospital stays to control graft site pain, and poor quality and quantity of the graft in elderly patients in whom fusion procedures are commonly performed.[12,21,26] The reported complications of iliac crest bone grafting have promoted

TABLE 3: Results of iliac crest autograft side questioning

Parameter	Value
correct answers	9 (36%)
confidence in correct answers	
guesses	7
NRS score	0/10
confident answers	2
NRS score	0/10 at rest; 3/10 w/ activity
NRS score	0/10 at rest; 4/10 w/ activity

research and the growth of a large bone biological industry to find the ideal autograft substitute.[6,15] However, numerous articles have called the complication rate into question, especially when considering baseline pain or when graft sites are reconstructed.[1,9,18,20]

The results of this pilot study appear to show that patients do not realize which iliac crest has been grafted after morselized allograft reconstruction of the bony defect is performed following the removal of autograft via one surgical incision. More patients actually guessed incorrectly (64%) than correctly (36%). If iliac crest autograft harvesting were the cause of significant local pain, as previously reported, one would expect the majority of patients to be able to indicate from which side the autograft was taken.

We acknowledge several weaknesses in this article, as we sought to perform a simple, easily replicable study to determine if patients suffer as much debilitating iliac crest pain after iliac crest autograft harvest as has been reported in the literature and presumed by patients. Since this is a pilot study, the sample size was very small. However, we believe the results warrant further consideration, and we welcome opportunities to incorporate our findings into a larger, multicenter study with more controls and variables. The surgeons reconstructed the bony defects with allograft as per their normal procedure. This article was not intended to study the effects of the reconstructed versus the unreconstructed iliac crests, but can serve as a springboard for future study. Several recent studies have addressed the effects of reconstructing iliac crest harvest sites.[2,3,7,10,23] We recognize another weakness that pertains to data collection: there was not reliable documentation of the volume of iliac crest autograft harvested in each patient. This is a potential confounder because it could be presumed that patients with larger volumes of autografts would have increased pain. However, the patients who were able to confidently identify the iliac graft site had 1- and 2-level fusions, which is less than the mean number of levels (3.1) in the study (Table 2).

The biologics of spinal fusion is an area of ongoing extensive research in the field of spine surgery to find an ideal alternative for spinal arthrodesis.[4,8,13,24] Iliac crest remains the gold standard in terms of performance, safety, and cost. We recognize that reconstructing the iliac crest defect with allograft creates some additional cost to the surgery. However, cortico-cancellous allograft bone is far less expensive than most of the synthetic bony extender products currently on the market. A cost analysis was not performed as part of this study because every hospital system has a different pricing contract with biological bony extender vendors. A comparative effectiveness analysis of allograft versus all bony extenders on the market is beyond the scope of this article but could resolve the issue if such a study is done prospectively. The majority of practicing spine surgeons and hospital administrators would agree that the per-volume cost of allograft is cheaper than the synthetic biologics. A cost driver for harvesting the autograft is the extra operating time and blood loss resulting from the harvest.[12,21] We did not measure the time taken or the specific blood loss attributable to harvesting the graft during surgery. Future studies could include timing the graft site harvest and measuring the blood lost using a separate suction line during that time.

Given the numerous bone grafting products currently available to the spine surgeon, selecting an appropriate graft can be intimidating. Literature supporting the use of these differing graft types is supported by poor-quality (Level III, IV, or V) or insufficient evidence. Thus, the iliac crest bone graft remains the gold standard for spinal arthrodesis, and our data indicate the absence of worsened pain and the inability to accurately identify donor site pain. These findings provide us with a baseline to continue using iliac crest autograft for patients.

We intentionally chose simple data and reporting methods to facilitate further study of this topic. Practicing spine surgeons in a variety of hospital settings can repeat this study, as can clinicians in large academic institutions with abundant research support staff that can administer and collect patient questionnaires. As surgeons work in their daily practice, they can consider utilizing the same techniques during their operations. If the patients return to the clinic complaining of iliac crest pain from the graft harvest, the surgeon can then ask, "Which iliac crest did I take?" As noted in our results, iliac crest harvesting can cause significant pain in some patients. However, most patients will not be able to identify in response to pain which iliac crest was harvested with any more accuracy than a coin flip.

Conclusions

The evolution of a variety of bone graft enhancers has increased the ability of the spine surgeon to achieve good results in spinal arthrodesis. However, none appear to be as safe and cost effective as iliac crest autograft. Our results indicate the inability of patients to clearly define their graft site after iliac crest autograft harvest with allograft reconstruction of the bony defect unless they have a separate skin incision. This simple, easily reproducible pilot study can be expanded into a larger, multiinstitutional investigation to provide more definitive answers regarding the ideal, safe, and cost-effective bone graft material to be used in spinal fusions.

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Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper. E.W.N. is a consultant for DePuy/Synthes and has speaking and/or teaching arrangements with DePuy/Synthes, BrainLAB, and Medtronic Navigation. He receives royalties from Globus Spine and is on the Scientific Advisory Board for K2M Spine and Medtronic Navigation. S.M.P., S.K., M.O., and G.R. have no conflicts of interest to disclose. A portion of the study was funded by the Gary and Lynne Sneed Family Neuroscience Research Fund.

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