



Clinical Study

Prospective study of iliac crest bone graft harvest site pain and morbidity

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Abstract

BACKGROUND CONTEXT: Morbidity associated with autologous bone graft harvest is an important factor in determining the utility of expensive alternatives such as recombinant bone morphogenetic protein. The most frequently reported complication associated with graft harvest is chronic pain.

PURPOSE: To prospectively determine the degree of pain and morbidity associated with autologous iliac crest bone graft harvest and its effect on activities of daily living.

STUDY DESIGN: Prospective observational cohort study.

PATIENT SAMPLE: One hundred ten adult patients undergoing elective posterior lumbar spinal fusion surgery involving autologous iliac crest bone graft harvest.

OUTCOME MEASURES: Patient self-reported Visual Analog Scale (VAS) scores for pain and a study-specific questionnaire regarding activities of daily living.

METHODS: One hundred ten patients were prospectively enrolled. Postoperative VAS scores (0–100) for harvest site pain were obtained at 6-week, 6- and 12-month follow-up. Patients completed a 12-month questionnaire regarding the persistence of specific symptoms and resulting limitation of specific activities.

RESULTS: One hundred four patients were available for 1-year follow-up. Mean VAS pain scores (scale 0–100) at 6 weeks, 6 and 12 months were 22.7 (standard deviation [SD]: 25.9), 15.9 (SD: 21.5), and 16.1 (SD: 24.6), respectively. At 12 months, 16.5% reported more severe pain from the harvest site than the primary surgical site, 29.1% reported numbness, and 11.3% found the degree of numbness bothersome, whereas 3.9% were bothered by scar appearance. With respect to activity limitations resulting from harvest site pain at 1 year, 15.1% reported some difficulty walking, 5.2% with employment, 12.9% with recreation, 14.1% with household chores, 7.6% with sexual activity, and 5.9% irritation from clothing.

CONCLUSIONS: There is a significant rate of persistent pain and morbidity from iliac crest bone graft harvest when associated with elective spine surgery. Mean pain scores progressively decline over the first postoperative year. Nevertheless, harvest site pain remains functionally limiting in a significant percentage of patients 1 year after surgery. Rates of functional limitation are higher than previously reported and may be because of increased sensitivity of the prospective study design and targeted investigation of these specific symptoms. Validity of these findings is necessarily limited by patient ability to discriminate harvest site pain from alternative sources of back and buttock pain. © 2009 Elsevier Inc. All rights reserved.

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Bone graft; Iliac crest; Harvest site pain; Spinal fusion; Complications

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113 **Introduction**

114 A large number of autologous bone graft harvest
 115 procedures are performed each year in the United States,
 116 with the most common source being the iliac crest.
 117 Autologous iliac crest bone graft has long been considered
 118 the “gold standard” source of bone graft for spinal fusion
 119 surgery, providing fairly reliable fusion than in a variety
 120 of procedures. However, the graft harvest procedure carries
 121 the disadvantage of introducing a second surgical site with
 122 potential for both short- and long-term morbidity, including
 123 pain, infection, and neurovascular injury. Available studies
 124 have reported a wide range of complication rates from
 125 9.4% to 49%, with minor complication rates ranging
 126 from 6% to 39% and major complication rates ranging from
 127 0.7% to 25% [1–8]. Consistently higher rates, mostly
 128 related to chronic pain, have been reported in patients un-
 129 dergoing spinal surgery compared with other types of sur-
 130 gery such as maxillofacial reconstruction [9,10]. Overall,
 131 the most commonly reported complications in most reviews
 132 include chronic harvest site pain, sensory changes, gait ab-
 133 normalities, infection, and unsatisfactory cosmesis [11].

134 Published studies evaluating iliac crest bone graft
 135 harvest complications must be viewed cautiously. The
 136 reported risk of specific complications such as pain and
 137 sensory loss varies widely among studies in large part
 138 resulting from variations in study methodology and patient
 139 population. The vast majority of investigations in this area
 140 have been retrospective studies, which are well known to be
 141 inaccurate at calculating rates of postoperative complica-
 142 tions (Table 1).

143 Because of the need for quantitative data and the relative
 144 scarcity of prospective studies in this area, a prospective
 145 analysis of iliac crest bone graft harvest site pain in patients
 146 undergoing elective posterior lumbar spinal surgery was
 147 performed.
 148
 149

150 **Materials and methods**

151 The study protocol was reviewed and approved by the
 152 Institutional Review Board. The study population consisted
 153 of adult patients undergoing elective posterior lumbar spi-
 154 nal surgery in which autologous iliac crest bone graft har-
 155 vest was a planned part of the procedure. Four surgeons
 156 participated in a single institution.
 157

158 Preoperative demographic and clinical data were col-
 159 lected including age, sex, insurance, employment status,
 160 primary and secondary diagnoses, associated medical co-
 161 morbidities, and medications.

162 For all procedures, graft was harvested from the poste-
 163 rior iliac crest using the midline lumbar incision when pos-
 164 sible. If a separate skin incision was required, a longitudinal
 165 incision placed away from the most prominent aspect of the
 166 iliac crest was made in an effort to minimize the incidence
 167 of scar sensitivity. The iliac crest contour was preserved by
 168 either harvesting cancellous bone from between the inner

and outer tables (same incision) or corticocancellous strips
 below the crest (separate incision). Postoperatively the skin
 and local soft tissue were anesthetized with 0.5%
 bupivacaine.

Postoperative data regarding pain were collected at
 6-week, 6- and 12-month follow-up and consisted of Visual
 Analog Scale (VAS) scores for local pain at the iliac crest
 bone graft harvest site and at the primary surgical site.
 VAS was assessed on a continuous scale from 0 (no pain)
 to 100 (worst pain imaginable).

Because of the difficulty patients often experience dis-
 criminating harvest site pain from other potential sources
 of back and buttock pain, a full-time dedicated research as-
 sistant was hired to supervise administration of the pain
 scores and final questionnaire. This individual coached
 each patient to carefully record and remember their preop-
 erative baseline back, buttock, and leg pain distribution, se-
 verity, and quality. At each follow-up visit, patients sat with
 the research assistant to determine to what degree the actual
 iliac crest harvest site appeared responsible for additional
 pain.

At 12-month follow-up, patients also completed a 10-
 item questionnaire specifically addressing the harvest-site
 symptoms and any resulting functional limitations.

Resulting data were compiled for the study population as
 a whole. Subgroup analyses were then performed using
 Student *t* test and Fisher exact test. Significance was set
 at $p=.05$.

197 **Multivariate analysis**

198 Univariate analysis was performed comparing the
 199 12-month VAS scores for graft site pain, primary surgical
 200 site, and lower extremity pain across a series of potential
 201 risk factors for chronic pain, including a history of chronic
 202 pain after previous surgery, diagnosis of a chronic pain syn-
 203 drome, such as fibromyalgia, history of chronic narcotic
 204 medication usage, diagnosis of depression, patient age,
 205 and smoking status. Two-sided *p*-values were calculated us-
 206 ing two independent sample *t* test. Simple linear regression
 207 modeling was used to determine the effect of significant
 208 variables (defined as $p<.1$ on univariate analysis) on VAS
 209 score. Because VAS scores were not normally distributed
 210 (left-skewed), a square root transformation of each VAS
 211 was performed to approximate a normal distribution before
 212 analysis. The data were then transformed back before re-
 213 porting results. All statistical analyses were performed us-
 214 ing SAS software, release 9.1 (SAS Institute, Inc., Cary,
 215 NC, USA).
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219 **Results**

220 One hundred ten patients were prospectively enrolled.
 221 Six patients were lost to follow-up before 12 months. The
 222 final study group consisted of 104 patients. Females slightly
 223 outnumbered males (56 females, 48 males). Average patient
 224

Table 1
Comparison of published studies of iliac crest bone graft harvest site pain and morbidity

Study	Design	No. of patients	Population	VAS/NRS pain score 6 wk	VAS/NRS pain score 6 mo	VAS/NRS pain score 12 mo	Functional evaluation performed
Current	Prospective	104	Posterior lumbar fusion	2.3 (0–10)	1.6 (0–10)	1.6 (0–10)	Yes
Dimar et al. [21]	Prospective FDA-IDE comparison BMP vs. iliac crest graft	98	Single-level posterior instrumented lumbar fusion	8.0 (range not defined)	7	7	No
Silber et al. [19]	Retrospective	134	Anterior cervical fusion	N/A	N/A	N/A	Yes
Sandor et al., Oral Surg Oral Med Oral Pathol Oral radiol Endod 2003	Prospective comparison of open harvest to trephine	76	Maxillofacial reconstruction	3.0–6.2 (0–10) at Day 1	1.6–5.8 (0–10) at Day 3	N/A	No
Ahlmann et al., J Bone Joint Surg 2002	Retrospective comparison of anterior and posterior iliac crest graft	108	Chronic osteomyelitis	N/A	N/A	N/A	No
Robertson and Wray [20]	Prospective	97	Posterior cervical, thoracic, and lumbar fusion	1.6 (0–10)	1.8 (0–10)	1.2 (0–10)	No
Mirovsky and Neuwirth, Spine 2000	Prospective comparison outer table vs. between cortexes	60	Lumbar fusion	52–56% with >5 (0–10) at 1 wk	17–24% with >5 (0–10) at 3 mo	17–24% with >5 (0–10)	No
Burstein et al., Plast Reconstr Surg 2000	Prospective comparison of open harvest to bone grinder or trephine	55	Maxillofacial reconstruction	N/A	N/A	N/A	No
Skaggs et al., Spine 2000	Retrospective	214	Children aged 3–18 undergoing spinal fusion	N/A	N/A	N/A	No
Hill et al. [14]	Retrospective questionnaire	73	Undefined	N/A	N/A	N/A	No
Sawin et al. [8]	Retrospective comparison of iliac crest graft to rib graft	600	Anterior and posterior cervical fusion	N/A	N/A	N/A	No
Schnee et al., Spine 1997	Retrospective	144	Anterior cervical fusion	N/A	N/A	N/A	No
Colterjohn and Bednar, JBJS 1997	Retrospective control and prospective study group, incision parallel to crest vs. perpendicular	110	Spinal fusion	6–7 (0–10) at 1 mo	2–3 (0–10) at 6 mo	N/A	No
Goulet et al. [9]	Retrospective	119	Various orthopedic procedures including spinal fusion	N/A	N/A	N/A	Impact on gait only
Kreibich et al., JBJS 1994	Retrospective comparison of open vs. percutaneous harvest	86	Not defined	N/A	N/A	N/A	No
Canady et al. [4]	Retrospective questionnaire	50	Maxillofacial reconstruction	N/A	N/A	N/A	No

VAS/NRS, Visual Analog Scale/Numerical Rating Scale score; FDA-IDE, ; BMP, bone morphogenic protein; N/A, not available.

age was 50.4 years (range, 23–88 years). Insurance status included 9% workers' compensation. Eighty-one percent of them were actively employed at the time of surgery. Primary and secondary diagnoses included spinal stenosis in 40% of patients, spondylolisthesis in 36%, spondylolysis in 13%, degenerative disc disease in 13%, scoliosis or flat-back syndrome in 6%, and spondylosis in 8%.

The mean VAS scores for harvest site pain were 22.7 (25.9) at 6 weeks, 15.9 (21.5) at 6 months, and 16.1 (24.6) at 12 months. A relatively wide range of reported pain scores was observed throughout the study period as demonstrated by the consistently large standard deviation for each time point.

There was no significant difference in pain based on primary diagnosis. Patients who underwent surgery for a primary diagnosis of lumbar degenerative disc disease reported mean VAS scores of 28.1 (28.7) at 6 weeks, 15.7 (22.4) at 6 months, and 16.1 (24.8) at 12 months. For patients with a primary diagnosis of lumbar spinal stenosis, mean scores were 19.7 (26.2), 17.5 (25.0), and 11.2 (21.4), respectively.

No significant difference in reported pain was identified based on age, gender, or the number of levels fused.

The effect of insurance status was examined among patients undergoing lumbar spinal surgery. Significantly greater pain levels were reported by patients receiving workers' compensation as compared with the nonworkers' compensation subgroup. Mean pain scores were approximately 75% greater in the workers' compensation subgroup at 6 weeks and nearly 400% greater at 1 year. These differences were statistically significant.

Pain scores did not vary significantly among individual surgeons or on the basis of bone graft harvesting technique, that is, via the primary posterior lumbar midline incision or a second posterior longitudinal iliac crest incision (data not shown).

The 12-month questionnaire revealed relatively high rates of persistent symptoms resulting from iliac crest bone graft harvest. Persistent pain at the harvest site was reported by 16.5% that was greater than pain from the primary surgical site. Noticeable numbness was reported by 29.1% and 11.3% found the numbness bothersome. The percentage bothered by the appearance of their scar was 3.9.

Patient reported rates of functional disability were also greater than previously published. Because of persistent graft site pain, 15.1% reported difficulty walking, 5.2% difficulty with their job, 12.9% difficulty with recreational activities, 14.1% difficulty with household chores, 7.6% difficulty with sexual activity, and 5.9% irritation from clothing. Rates of functional disability were comparable between workers' compensation and nonworkers' compensation populations across specific activities with the exception of the ability to work in which patients receiving workers' compensation reported significantly greater rates of disability.

There were no complications with respect to the bone graft harvest procedure that required reoperation in any

patient during the time period of the study. Specifically, there were no significant hematomas, infections requiring surgical irrigation or debridement, iliac crest fractures or soft tissue herniation.

Multivariate analysis

An association with chronic graft site pain was identified for diagnosis of a chronic pain syndrome and chronic narcotic usage only (Table 2). Depression was associated with increased postoperative extremity pain, but not harvest site pain. Smoking status was associated with increased postoperative back pain, but not harvest site pain. Multivariate analysis revealed that chronic narcotic use was the only associated risk factor for chronic harvest site pain (Table 3).

Discussion

There is currently no consensus regarding the true morbidity of iliac crest bone graft harvesting. Reported rates of chronic harvest site pain vary greatly in the literature depending on study design and study population (Table 1). Goulet et al. found persistent pain in 30 of 71 (42.3%) patients undergoing spinal surgery at 6 months compared with 3 of 16 (18.7%) undergoing nonspinal surgery [9]. At 2 years, this rate had decreased to 15 of 71 (21.1%) and 1 of 16 (6.2%), respectively. Chronic pain rates are generally higher in studies specifically addressing populations of spine surgery patients, but even within this population there is a wide range of reported rates depending largely on study design. Based on chart review data, Younger and Chapman reported a minimal 2.5% rate of persistent pain at 6 months [6]. By comparison, Summers and Eisenstein reported a 49% rate of chronic donor site pain (25% severe and 24% "acceptable") in a series of 290 patients undergoing posterior lumbar spinal fusion [2].

It has been suggested that the higher reported rates in spine surgical patients may reflect difficulty in distinguishing persistent back pain from harvest site pain. This is supported by the finding that the underlying diagnosis appears to be a factor in determining the likelihood of persistent harvest site pain. Fernyhough et al. studied 151 spinal fusion patients and found that the rate of chronic harvest site pain in patients undergoing surgery for back pain and degenerative spinal disease was twice as high as in patients undergoing surgical stabilization for acute spinal trauma [12]. The present study attempted to address this issue by its prospective design, and during administration of the VAS measurements and questionnaire, a specific effort was made to have patients distinguish harvest site pain from pain related to the primary surgical procedure or preoperative symptoms. Nevertheless, even in this study, patients undergoing surgical treatment for degenerative disc disease continued to report higher rates of harvest site pain

Table 2
Univariate analysis of potential risk factors for chronic pain

Risk factors	p-Values for univariate analysis		
	VAS harvest site	VAS back	VAS leg
History of chronic pain after previous surgery	0.3615	0.0065	0.0006
Diagnosis of chronic pain syndrome, eg fibromyalgia	0.0330	0.0317	0.2221
History of chronic narcotic medication usage	0.0009	0.0019	0.0011
Diagnosis of depression and use of prescription antidepressants	0.4605	0.0812	0.0372
Age at surgery	0.5413	0.1791	0.4325
Smoking status	0.0912	0.0090	0.3761

VAS, Visual Analog Scale score.

as compared with patients undergoing surgery for spinal stenosis.

Specific aspects of surgical technique appear to play a limited role in the incidence of harvest site pain. When using the posterior midline lumbar incision for graft harvest, a fascial splitting approach has been associated with a lower complication rate compared with a subcutaneous approach (3% vs. 15%), but no significant difference in pain rates has been shown with harvest through the primary surgical incision as opposed to a separate incision [12,13]. Similarly, in our study, we found no difference in pain rates depending on whether graft was harvested through the primary surgical incision with a subcutaneous approach or a separate skin incision over the iliac crest.

In the past, dissatisfaction with scar appearance was reported more frequently in the young female population [3]. However, cosmetic concerns are now recognized as a universal issue regardless of age or gender. One questionnaire study revealed that 8.2% of patients felt their scar was “totally unacceptable.” Dissatisfaction with scar appearance correlated with general dissatisfaction with the procedure, suggesting that this may have been a confounding factor [14]. Harvesting graft through the principal surgical incision as opposed to a separate incision eliminates the risk of dissatisfaction with the appearance of a separate scar but may increase the risk of other complications [12]. In our study, among those patients with a separate incision, relatively few (3.9%) reported dissatisfaction with the appearance of their harvest site scar.

An economic evaluation of bone morphogenic protein (BMP) versus autogenous iliac crest bone graft in spinal fusion concluded that the most important factor determining the potential value of bone graft substitutes is disability related to harvest site pain and nonunion rates [15].

Table 3
Multivariate analysis of risk factors for chronic harvest site pain

Risk factors	VAS harvest site (square root)		
	β coefficient	Standard error	p-Value
Diagnosis of chronic pain syndrome, eg fibromyalgia	1.2149	0.7777	.1217
History of chronic narcotic usage	1.3247	0.4909	.0083
Smoking status (no smoking as reference group)	0.8929	0.5893	.1332

VAS, Visual Analog Scale score.

Therefore, an important finding of this study is the relatively high rate of patient-reported difficulty with routine daily activities 1 year after surgery that the patients attributed at least in part to chronic pain from their bone graft harvest site. When asked specifically about these activities, 15.1% reported that chronic harvest site pain contributed to difficulty walking, 5.2% reported difficulty with their job, 12.9% with recreational activity, 14.1% with household chores, 7.6% with sexual activity, and 5.9% irritation from clothing. These rates are toward the higher end of the range previously reported in other studies and are likely because of the prospective study design in which information regarding the effect of bone graft harvest site pain was specifically sought. It has been well-established that complication rates are underreported in retrospective study designs.

The highest reported rate of functional limitation was reported for ambulation. Difficulty walking and gait ambulation have been reported in previous studies of iliac crest bone graft harvest. The so-called gluteal gait abnormality has been reported in approximately 3% of patients [16–18]. After posterior graft harvest, patients may report weakness with stair climbing or arising from a seated position [11]. Goulet et al. reported a 12.6% rate of ambulation difficulty at 6 months in a group of predominantly spinal surgery patients undergoing posterior graft harvest. This figure declined to 5.7% at 2 years [9].

In the only other study to specifically address the impact of chronic harvest site pain on specific functional activities, Silber et al. performed a questionnaire study of 134 patients undergoing anterior iliac crest bone graft harvest for anterior cervical fusion and found higher rates of chronic morbidity than previously reported, including 26.1% for donor site pain, 15.7% for abnormal sensation, and surprisingly high rates of functional impairment with respect to

ambulation (12.7%), recreational activity (11.9%), work activity (9.7%), activities of daily living (8.2%), sexual activity (7.5%), and household chores (6.7%) [19]. This retrospective study was limited, however, by recall bias and the fact that patients were questioned at variable follow-up times with respect to the index surgery. Although it suggested that morbidity from bone graft harvest was a significant problem, the time course of postoperative pain could not be determined and true rates of functional impairment at a specific time point after surgery could not be calculated. It should also be noted that their study involved exclusively patients undergoing anterior graft harvest in contrast to our study that focused solely on posterior iliac crest harvest. Current practice patterns of spinal surgery involve much higher rates of posterior as opposed to anterior iliac crest bone graft harvest. Nevertheless, it is of interest that the functional impairment rates reported by Silber et al. are generally comparable with those observed in the present study.

Overall, very few prospective studies have been reported. The largest prospective study reported, by Robertson and Wray involved 106 patients undergoing posterior spinal fusion and posterior iliac crest bone graft harvest [20]. In contrast to recent retrospective studies, these investigators found a relatively low rate of significant harvest site pain at 12 months, with only 12% reporting a VAS score greater than 3. This relatively low score may be resulting from inclusion of both cervical and lumbar spine patients in the study. Significantly less bone graft material is typically harvested for cervical spine fusions. Overall, the minor complication rate was found to be 35% and consisted mostly of insignificant pain and tenderness. The rate of local sensory loss was 10%. An analysis of how these complaints related to functional limitations was not performed.

A prospective blinded study comparing recombinant human BMP (rhBMP) to autologous iliac crest bone graft in single-level posterior instrumented lumbar fusion included an attempt to assess harvest site pain [21]. This study used a hip pain score as a surrogate for harvest site pain, but the data are difficult to interpret because of relatively higher reported hip pain among patients before surgery versus after surgery. Although patients undergoing bone graft harvest reported lower mean improvement in the bodily pain component of the short form-36 compared with patients receiving rhBMP, this difference did not achieve statistical significance.

The major limitation of this study is shared by previous studies of harvest site pain and reflects the questionable ability of patients to distinguish pain resulting from the bone graft harvest procedure from either their preoperative pain or pain from the primary lumbar spinal surgery. To the extent that pain is a purely subjective phenomenon that can only be identified and characterized by the patient, this issue remains unresolved. Future studies in this area should consider incorporating randomization of the side of bone

graft harvest and blinded evaluation by both patient and observer. Careful documentation of any lateralization of preoperative buttock pain would also be critical.

In summary, this study found a relatively high rate of persistent pain and morbidity after posterior iliac crest bone graft harvest 1 year after surgery. Average VAS scores suggested typically mild pain levels but with significant individual variation, and average pain levels for the study population improved for up to 6 months after surgery. Average harvest site pain remained stable between 6 months and 1 year. Harvest site pain appears to be a cause of persistent functional limitation in many patients as long as a year after surgery, and these rates may be much higher than previously thought. The higher rates of pain and functional limitation found in this study compared with previous studies may be because of its prospective design. Finally, chronic narcotic pain medication use may be a risk factor for higher reported levels of persistent harvest site pain.

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