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Anatomical reconstruction of donor site after large iliac crest graft harvest with equivalent iliac crest allograft. A prospective controlled study

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Abstract. – BACKGROUND: Iliac bone graft harvesting is a common procedure in spinal surgery and trauma center for spinal fusion and nonunion of the extremities.

AIM, PATIENTS AND METHODS: To compare the pain and cosmetic outcomes of patients undergoing iliac crest anatomical reconstruction using equivalent iliac crest allograft (R group) with those of patients without reconstruction of the iliac crest defect (NR group), a prospective nonrandomized controlled study was conducted.

RESULTS: In R group, the intensity and prevalence of pain were significantly lower than those in NR group. Cosmetic outcome and satisfaction score were also significantly improved in R group. One patient of R group suffered from lipolysis and superficial infection which healed by regular dressing change for two weeks. There were no cases of allograft displacement, implant loosening, internal fixation breakage or immunological rejection. Seven patients in NR group had significant pain related to the tenting of skin over the defect. Radiologic incorporation of pelvis was documented in all patients except four having partial re-sorption of the allograft. Early fibrous healing and the late creeping substitution were noted in all patients of R group.

CONCLUSIONS: Equivalent iliac crest allograft provides an effective alternative for iliac crest anatomical reconstruction, leading to reduced donor site pain and better cosmesis.

Key Words:
Iliac crest reconstruction, Equivalent iliac crest allograft, Donor site morbidity.

Abbreviations

VAS = visual analog scale
R = reconstructed group
NR = non-reconstructed group

Introduction

Many novel bone implantation materials including MmacroPore sheet, Inductive Conductive Matrix[1], methylmethacrylate[2], tricalcium phosphate[3], and polylactic acid mesh[(4)] have been reported in recent years. However, autogenous bone graft is still a widely used method for the clinical orthopedics. Especially, iliac bone is the most common donor site. Despite widespread use of allograft, cages, and artificial bone, autologous bone graft still continues to be widely preferred in spinal surgery and treatment of nonunion and bone defect because its favorable osteoinductivity and osteoconductivity[5].

However, harvesting a large graft from the iliac crest will create an extensive void in the iliac crest contour. The complications of iliac donor sites such as varying degrees of chronic pain, local tissue collapse and deformation of iliac area are repeatedly encountered as reported[6,7]. Muscle or visceral herniation and gait abnormality also arise secondary to the great graft harvest[4].

Several improvisations in the iliac crest graft harvest techniques have been suggested. Rounding of the edges of the defect followed by meticulous multilayered closure can minimize the tenting and irritation of the skin overlying the defect. The cosmetic outcome, however, is seldom improved[4].

Various biomaterials such as MacroPore sheet, Inductive Conductive Matrix[1], methylmethacrylate[2], tricalcium phosphate[3], polylactic acid mesh[4], bioactive ceramic spacer[8,9], polytetrafluoroethylene[10] and autologous rib graft have been used in reconstruction of the iliac defects. However, all these choices can't give an anatom-

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ical reconstruction. Ito et al[3] analyzed the benefit of reconstructing iliac crest voids with tricalcium phosphate in a prospective randomized controlled trial. However, the size of the reconstructed iliac crest void in this trial was relatively small such as one created after a cervical discectomy or corpectomy.

Bapat et al[10] investigated the benefit of reconstruction in large iliac crest defect created after reconstruction of thoracic or lumbar vertebral bodies in a non-randomizedly controlled trial. It was the first prospective controlled study to examine the outcome of reconstruction using autologous rib graft in large iliac crest defects, which provides a cheap and effective alternative for iliac crest reconstruction. Nevertheless, using autologous rib graft requires making an incision in chest and this is unacceptable especially in the young women.

Allograft has been widely used for the bone defect and reconstruction now because iliac crest allograft can be dissected into similar contour with donor site. Therefore, we deduce that anatomical reconstruction with equivalent iliac crest allograft may be one feasible choice. Although not randomized, this is the first prospective controlled study to examine the outcome of anatomical reconstruction using equivalent iliac crest allograft in large iliac crest defects.

Patients and Methods

A prospective nonrandomized controlled study was conducted from May 2005 to May 2008. Twenty consecutive patients who underwent large iliac crest graft harvest for bone defect and nonunion associated with extremity fractures were selectively given anatomical reconstruction of iliac defect using equivalent iliac crest allograft.

Inclusion criteria: Patients who underwent structural iliac crest autograft for bone defect and nonunion associated with extremity fractures; iliac defects more than 40 mm (length) × 30 mm (depth) after graft harvest; 18-60 years. Exclusion criteria: Patients in whom the iliac crest void less than 40 mm (length) × 30 mm (depth); less than 18 or more than 60 years; allergic; bone defect and nonunion associated with pathologic fractures; intolerant to more operations due to poor health condition. All patients were given an informed consent about the risk and complication of anatomical reconstruction of iliac defect using equivalent iliac crest allograft or solely suture.

All patients who underwent reconstruction of the iliac crest using equivalent iliac crest allograft were categorized into the reconstructed group (R group), which was compared with 20 patients at the same stage for whom the iliac crest void was not reconstructed (NR group). Three kinds of commercial allogeneic iliac blocks (6 cm × 5 cm, 3 cases; 5 cm × 4 cm, 13 cases; 4 cm × 3 cm, 4 cases) were used respectively.

All cases were operated by one group specialized in fracture and nonunion. The demographic data of these patients were presented in Table I. Both groups were well matched as regards the age, sex, and dimension of the iliac crest defect.

Surgical Technique

According to the X-ray films and operative findings, the volume of the bone graft required for bone defect and union was determined. A skin incision over the crest was made 2 cm posterior to the anterior superior iliac spine. Soft tissue was separated carefully from sub-periosteal to avoid the destruction, reduce bleeding and prevent the formation of intra-abdominal hernia content. Donor site was located at 2 cm backward from the anterior superior iliac spine. Required amount of iliac crest was exposed and measured with Vernier caliper. Bone graft was harvested using an osteotome, taking care not to fracture the graft or edges of the iliac defect (Figure 1).

Table I. The demographic data of two groups and their characteristics.

	R group	NR group
No. patients	20 (22 iliac crest)	20 (20 iliac crest)
Female patients	12 (14 iliac crest)	9 (9 iliac crest)
Mean age (yrs)	35.4 (18-56)	37.31 (21-60)
Femur nonunion	10	8
Humerus nonunion	6	7
Tibia nonunion	4	5
Average dimension of iliac crest defect	21.7 (14-30 cm^2)	19.4 (12-30 cm^2)

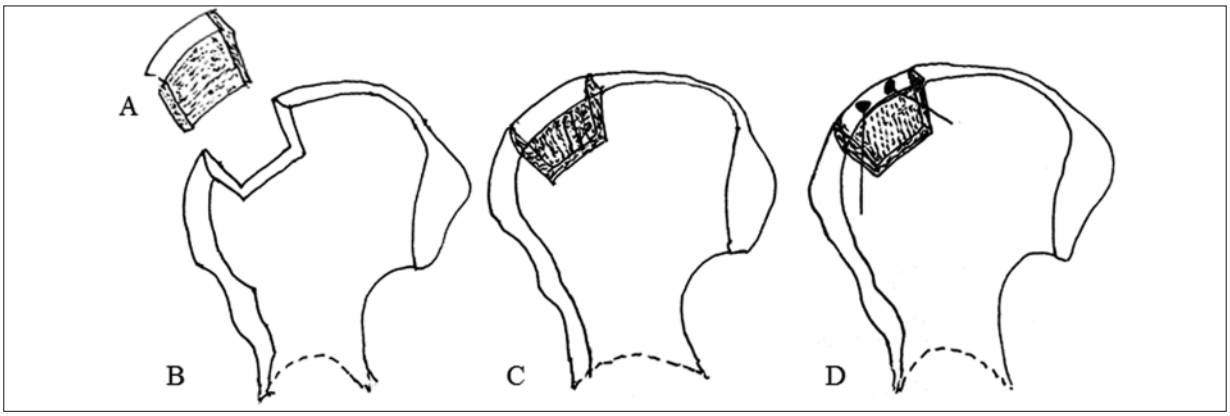

Figure 1. The procedure of anatomical reconstruction of donor site after large iliac crest graft harvest with equivalent iliac crest allograft. ***A,*** Equivalent iliac crest allograft. ***B,*** Harvesting a large graft from the iliac crest created an extensive void in the iliac crest contour. ***C,*** Equivalent iliac crest allograft was gently impacted into the defect to restore the iliac contour. ***D,*** Equivalent iliac crest allograft was fixed with two cannulated screws.

In R group, equivalent iliac crest allograft that matched the contour of the excised graft was selected and impacted gently into the donor site. One or two hollow compression screws were used to fix the allograft to the ilium. Soft tissue was sutured anatomically on the iliac crest (Figure 2). In NR group, sharp cortical edges of the defect were rounded off using an osteotribe. Adequate irrigating and drainage were done before closing the incision. Soft tissue was sutured in natural position with a tension-free closure.

Clinical Assessment

The clinical assessment was performed at 1 month, 3 months, 6 months, 12 months and 24 months, respectively. Table II summarized the various clinical parameters assessed.

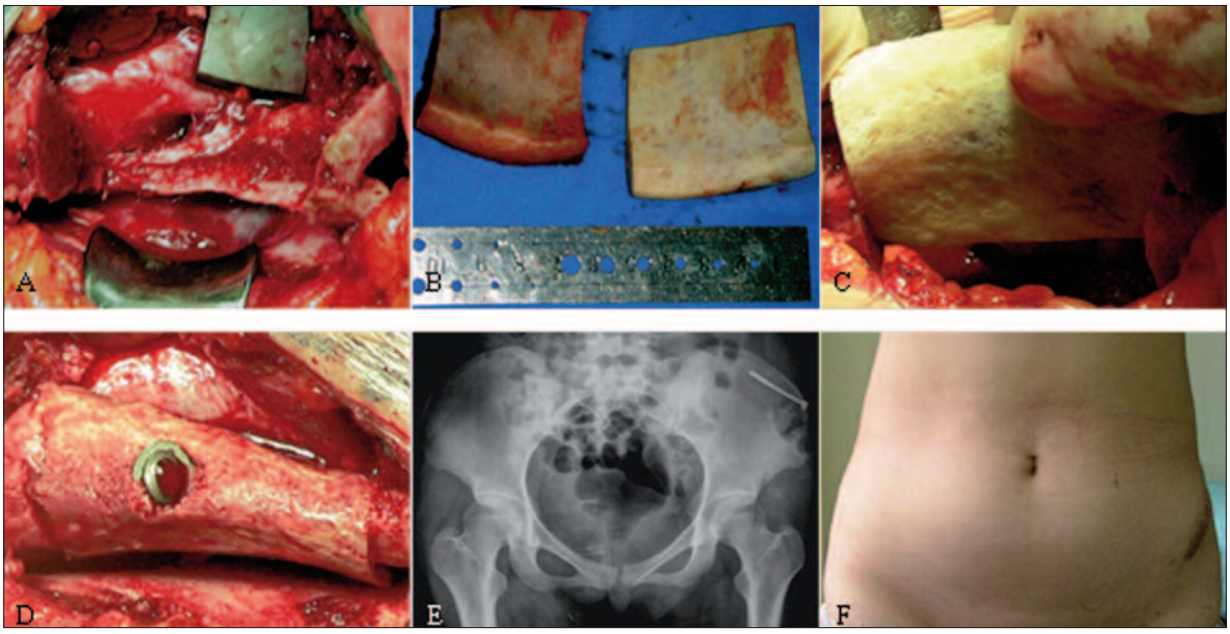

Figure 2. A 21 years old female, supracondylar and intercondylous nonunion and defect of humerus, had experienced two operations and one iliac autogenous bone graft. ***A,*** Mass bone defect of crest of ilium after osteotomy. ***B,*** Measuring and selecting allogenic iliac block according to the size of autograft. ***C,*** Implanting allogenic iliac block. ***D,*** Allograft was fixed with cannulated nail. ***E,*** Allograft was stable and the shape of crest of ilium was integrated 6 months after operation. ***F,*** Profile of pars iliac remained perfect postoperatively.

Table II. Clinical assessment of iliac crest donor site.

Pain
Visual analog scale (Pain VAS)
Tenderness at donor site
Functional disability
Lifting weights
Walking limp (Trendelenburg test positive)
Going upstairs/downstairs
Wearing waist belt
Sleeping on the operated site.
Cosmesis
Visual analog scale (cosmesis VAS)
Morphology of the defect (grade 1-2)
Grade 1: round contour or flat contour
Grade 2: shallow depression (< 1 cm depth)
Grade 3: deep trough (> 1 cm depth)
Degree of satisfaction
Visual analog scale (satisfaction VAS)
Clinical complications
Skin tenting, necrosis or irritation
Bursitis
Scar hypertrophy
Infection
Herniation (muscular or visceral)
Thigh numbness (meralgia paresthetica)
Immune response (effusion, fever, and red swelling)
Delayed healing of incision
Shifting and loosening of allograft, breakage of internal fixation
Secondary fracture
Internal fixation irritation
Hematoma
Limp

Independent Clinical Observer

An independent clinical observer blinded to the purpose of the procedure was requested to analyze the clinical outcome with the help of a predesigned questionnaire. The patients were asked to comment only on the donor site problems to differentiate from the pain at surgical site.

Pain and Functional Disability

The intensity of pain was assessed with a visual analog scale (pain VAS). Functional disability assessment was based on whether the patient had pain or discomfort during routine daily activities like lifting weights, walking, going upstairs/downstairs, wearing waist belt, or sleeping on the operated site.

Cosmesis and Degree of Satisfaction

The cosmesis was assessed with visual analog scale (Cosmesis VAS). The independent observer and the patients were separately asked to judge the cosmetic appearance using the cosmesis VAS. Morphology of the defect was graded according to the criteria established by Bapat et al[10] (Table II). Grade 2 and 3 were rated as poor cosmetic grades. The degree of satisfaction was assessed with visual analog scale (Satisfaction VAS). The patients were asked to give a self-evaluation to the results of donor sites using the Satisfaction VAS. The donor site was also assessed for the presence of complications (Table II).

Radiologic Assessment

Radiologic assessment was done at one week, 1 month, 3 months, 6 months, and 12 months using posterior-anterior radiograph view of pelvis. Abnormalities of radiograph including bone block shifting, loosening, breakage of internal fixation, secondary fracture, bone re-sorption, formation of mass bony callus, and style of bone union were recorded detailedly.

Statistical Analysis

Statistical analysis was performed using χ^2 test for non-parametric data and the Mann Whitney test for parametric data. For two patients who were given a reconstruction of iliac crest in two sides, each side was considered as one case. Significance was determined at the $p = 0.05$ level.

Results

Pain

The pain VAS showed a decreasing trend in both groups (Table III). Intensity of pain was significantly lower in the R group than that of the NR group at all stages. There was statistically significant difference between the scores in all follow-ups ($p < 0.001$).

At the final follow-up, tenderness on superficial palpation was detected in 3 patients of the R group and 6 patients of the NR group. In the R group, no patients were recorded high pain VAS. One of the 3 patients had re-sorption of allograft on the radiograph. Another two patients complaint of irritation of internal fixation.

Functional Disability Assessment

In the R group, there were 4 patients who complaint of irritation of internal fixation. Of them, 2 patients still complaint of tenderness occasionally when wearing waist belt and sleeping on the operated site after internal fixation was taken out, while another 2 patients felt well. In the NR group, 7 patients (35%) reported pain af-

Table III. Prevalence of pain and pain VAS scores in the R and NR groups at consecutive follow-up periods

Follow-up	NR Group	R Group	*p*
1 month			
Prevalence of pain	15 (75%)	4 (18.1%)	0.0005
Average pain VAS	3.73 ± 2.41	0.62 ± 1.5	< 0.001
3 months			
Prevalence of pain	13 (65%)	3 (13.6%)	0.0007
Average pain VAS	3.23 ± 1.78	0.47 ± 1.19	< 0.001
6 months			
Prevalence of pain	13 (65%)	3 (13.6%)	0.0008
Average pain VAS	2.98 ± 1.74	0.35 ± 1.01	< 0.001
12 months			
Prevalence of pain	10 (50%)	3 (13.6%)	0.0001
Average pain VAS	2.30 ± 1.54	0.28 ± 0.98	< 0.001
24 months			
Prevalence of pain	6 (30%)	3 (13.6%)	0.0002
Average pain VAS	1.13 ± 1.37	0.22 ± 0.86	< 0.001

ter trivial trauma and discomfort on wearing belt around the waist. Five patients (20%) were uncomfortable while sleeping on the operated side. There was no functional disability when walking and going upstairs/downstairs in both groups.

Cosmesis and Degree of Satisfaction

There was a statistically significant difference for the average cosmesis VAS scores and satisfaction VAS between the R and NR groups (Table IV). The prevalence of grade 2 and 3 type of defects (poor cosmetic grades) was significantly higher in the NR group n = 16 (80%), $p < 0.001$. Four patients who had grade 1 type of defects were relatively fatty.

Clinical Complications

In R group, one patient suffered from lipolysis and superficial infection which healed by regular dressing change for two weeks. There were 4 patients complaint of irritation of internal fixation. Of them, 2 still complaint of tenderness occasionally when wearing waist belt and sleeping on the operated site after internal fixation was taken out, while another 2 felt well. There were no cases of allograft displacement, implant loosening, internal fixation breakage or immunological rejection. In NR group, there was one scar hypertrophy and one thigh numbness which disappeared after one year. No surgical re-intervention was required to treat the complication.

Table IV. Cosmesis and degree of satisfaction result in the R and NR groups.

	NR group	R group
Cosmesis VAS	4.81 ± 2.33	0.4 ± 0.62
Good cosmesis (Grade 1)	4 (20%)	20 (100%)
Grade 1		0.62 ± 1.5
Poor cosmesis (Grade 2 and 3)		
Grade 2	7 (35%)	0 (0%)
Grade 3	9 (45%)	0 (0%)
Satisfaction VAS	5.5 ± 2.68	2.3 ± 1.49

Radiologic Assessment

Radiologic incorporation of pelvis was documented in all patients except four having partial re-sorption of the allograft. However, there was no collapses of soft tissue in all patients of the R group. Early fibrous healing and the late creeping substitution were noted. There were no signs of allograft displacement, implant loosening, internal fixation breakage or immunological rejection. In both groups, there was no intraoperative iliac crest fracture or secondary fracture of anterior superior iliac spine occurred.

Discussion

It is a common procedure to harvest autologous bone grafts from ilium in spinal surgery and treatment of bone nonunion. Autologous bone grafts are most frequently obtained from the iliac crest, which is still the best material for structural bone graft, and is still widely preferred in the treatment of nonunion and bone defect because its favorable osteoinductivity and osteoconductivity[10].

Several techniques about the iliac crest graft harvest have been reported to prevent the donor sites complications and achieved different degrees of success. The cosmetic outcome, however, is seldom improved. Various biomaterials have been used in the reconstruction of the iliac defects. Yet, they are usually inaccessible and can't give an anatomical reconstruction.

Complications of iliac graft harvesting are related to donor site, size and methods of acquiring iliac bone fragments. Technique of surgeon also plays an important role. With the gradual enlarging of harvesting areas, concomitant trauma and complications increase such as infection, hematoma formation, lateral femoral cutaneous nerve injury, abdominal hernia, chronic pain, and heterotopic ossification[4,11]. Pain of the donor site is the most common iliac complicatio[6,7]. Sasso et al[12] illuminated that 31% of patients still had persistent pain after 24 months, and 16% of patients were not satisfied with the appearance of donor site. Bojescul et al[13] determined artificial bone for filling of bone defect, however, bone defect still could be seen 1 year after surgery. Also, these did not significantly reduce the occurrence of pain in the area for the bone defect[13].

Bapat et al[10] explored the advantage of reconstruction of large iliac crest defect created after reconstruction of thoracic or lumbar vertebral bodies using autologous rib graft. Nevertheless, it is only an expedient measure in the anterior reconstruction of thoracic or lumbar vertebral bodies. It is not suitable for nonunion and bone defect of the extremities because another incision in chest has to be made. This is unaccepted to the young patients, specifically the women. Allograft has been widely used for the bone defect and reconstruction now. As we know, this is the first controlled trial about the iliac crest allograft for the anatomical reconstruction of iliac donor sites.

In this study, only one patient in R group suffered from lipolysis and superficial infection which healed by regular dressing change for two weeks. There were 4 patients complaint of irritation of internal fixation. Of them, 2 still complaint of tenderness occasionally when wearing waist belt and sleeping on the operated site after internal fixation was taken out, while another 2 felt well. There was no significant bone re-sorption, chronic pain and discomfort in the donor sites of the R group. Cosmetic outcome was excellent in the reconstructed patients and much superior to the non-reconstructed group.

Many theories have been proposed to explain the etiology of donor site pain such as trauma to the periosteum, muscle injury, neuroma formation, and adhesive scar formation[4,12]. We believed the results of this study might be related to the following four factors: (1) All the surgical incisions for the iliac crest graft harvesting were made at the inner edge of the iliac crest. Thus, wound scarring and pain caused by the belt friction could be significantly avoided; (2) Soft tissue was strictly separated from sub-periosteal to avoid the destruction and reduce bleeding. Furthermore, terminal points of the muscles and aponeurotic membrane were anatomically reconstructed. Above procedures could effectively prevent the contraction of muscles and soft tissue adhesion; (3) The anatomic reconstruction of iliac crest could eliminate bony prominence and prevent the tenting of the skin which was considered to contribute significantly to the development of donor site pain in large defects; (4) Moreover, iliac reconstruction can prevent contracture of the medial and lateral muscle of iliac wing. It was also good for the prevention of heterotopic ossification and abdominal herniation.

The clinical results of 20 patients showed that iliac crest allograft could reconstruct large patch of autologous iliac bone defect, which was not only a way for reconstruction of the iliac contour, but also a mean of prevention of complications.

In this study the patients were not randomized for the following reasons. Although all patients were given an informed consent, some patients

Table V. Clinical complications.

Complication	NR group	R group
Skin tenting and	0	0
pressure necrosis	0	0
Bursitis	0	0
Scar hypertrophy	1	0
Infection	0	1
Herniation	0	0
Thigh numbness	1	0
Immune response		0
Delayed healing of incision	0	1
Shifting and loosening of allograft, breakage of internal fixation		0
Secondary fracture secondary	0	0
Internal fixation irritation		4
Hematoma	0	0
Limp	0	0
Total patients	2 (10%)	5 (25%)

didn't choose reconstruction of the iliac crest. This might be attributed to economic constraint. Thereby, this study is confined by a relatively small sample size. Although both groups had comparable size of iliac crest defect, they differed with respect to the types of surgery they underwent. Some of them were for upper extremities and others lower extremities. The Authors agree that pain VAS recorded in this study might not be sufficiently specific to the donor site morbidity. Meticulous technique of graft harvest, hemostasis and wound closure are as important as reconstruction if these complications are to be avoided.

Conclusions

Equivalent iliac crest allograft reconstruction provides an effective alternative for iliac crest anatomical reconstruction. Reduced donor site pain and excellent cosmetic outcome are the major benefits of anatomical reconstruction of the iliac crest. However, we must emphasize that this is a preliminary study and hence is not strictly controlled. Nevertheless, we certainly acknowledge the need for a prospective, larger scale study to confirm and extend our findings.

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Conflict of Interest

None.

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