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ORIGINAL STUDY

Comparative study of autograft harvested from contra lateral proximal tibia versus the iliac crest for operative management of depressed tibial plateau fractures

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Our study evaluates differences in fracture healing, clinical outcome and donor site morbidity between iliac crest bone graft and contra lateral proximal tibial bone graft utilized for internal fixation of displaced tibial plateau fractures. In 34 patients requiring bone grafting, iliac crest was utilized in 16 cases and proximal tibia in the remaining 18. Fracture union was achieved in all patients in either group at a mean period of 14 weeks with no difference in the functional knee scores between the groups. The iliac crest group showed significantly higher visual analogue pain scores in the immediate post-operative period and greater donor site complications like superficial wound infection, incisional hernia and chronic pain compared to the proximal tibial group. Contra lateral proximal tibia offers a viable alternative to iliac crest as a donor site for bone graft with adequacy of graft quantity, ease of graft harvest and lesser donor site morbidity.

Keywords : bone graft; proximal tibia; iliac crest; tibial plateau fracture; donor morbidity

INTRODUCTION

Bone grafting has wide applications in orthopaedic surgery. Traditionally iliac crest has been used as the most common site to harvest bone graft. However numerous complications like infection, iliac crest fracture, hematoma, severe donor site pain, nerve injury and hernia have been reported. A recent systematic review found that the overall complication rate can be as high as 19 % (*6*). In 1991, O'Keefe et al reported proximal tibia bone graft (PTBG) as a useful alternative (*15*). The indication in their study was patients requiring cancellous bone graft for lower limb fractures and non unions. PTBG has also been used in maxillo-facial surgery (*4*) and more recently in foot and ankle surgery (*8*).

To our knowledge, contralateral PTBG has not been used in the operative fixation of tibial plateau fractures. We report our series of bone graft harvested from the proximal tibia and compared this with that obtained from the iliac crest. The aim was to evaluate differences in fracture healing, functional outcome and donor site morbidity between iliac crest bone graft (ICBG) and contralateral PTBG used for internal fixation of depressed tibial plateau fractures with associated metaphyseal defects.

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MATERIAL AND METHODS

All acute proximal tibial fractures, which needed internal fixation and supplementary bone grafting in the period between February 2010 and January 2014, were included in this retrospective comparative study. Out of 34 patients, ICBG was utilized in 16 (10 males and 6 females) initially and in the last two years contra lateral PTBG was used in the remaining 18 (11 males and 7 females). The injury demographics and treatment groups are detailed in table 1.

We used the anterior-lateral proximal tibia on the contralateral limb as the harvest area. The procedure was performed in all patients without a tourniquet. A three centimeter oblique skin incision was made two cm distal to a line joining the Gerdy's tubercle to just distal to tibial tuberosity. After soft tissue dissection and perisoteal elevation, a 13 millimeters diameter hand-held hollow bone mill (JJ Instruments, India), mounted on to a T-handle, was used in firm advancing motion to generate cortico-cancellous graft cylinder. Further use of a curved bone curette allowed adequate cancellous graft harvest as would be deemed necessary for the fracture support (Figure 1).

Fig. 1. — Graft being harvested from proximal tibia.

Fluoroscopy was used initially but was abandoned as experience was gained in the technique (Figure 2)

Once the graft was collected, periosteum was repositioned over the cortical defect and the wound closed after secure hemostasis. The patient was

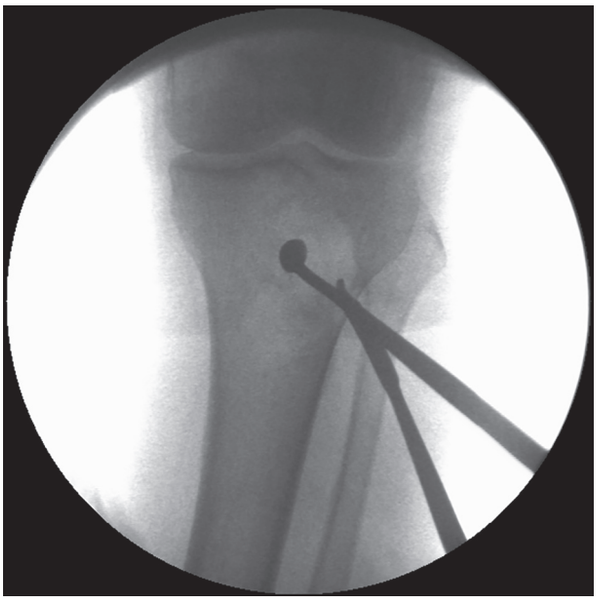

Fig. 2. — Fluoroscopy image during graft harvest

allowed full weight bearing on the graft harvested limb with mobility supports for balance.

Iliac crest bone graft was harvested with an incision centered over the iliac tubercle, and after careful dissection to avoid the lateral cutaneous nerve of the thigh, the crest was exposed. Starting about 2 centimeter posterior to the anterior superior iliac spine, a thin osteotome was used to harvest cortico-cancellous bone graft slivers. The wound was closed after adequate hemostasis.

Principles of fracture fixation with anatomical reduction, minimal soft tissue dissection and stable osteosynthesis were followed in all the displaced tibial plateau fractures. A ten- point visual analogue scale (VAS) score, where '0' was no pain and '10' being the most severe pain imaginable, was used in all patients to assess pain at the donor site in the first post-operative day. Clinical and radiological assessments of the fracture healing were made at regular intervals. No patient was lost to follow-up in the study. American Knee Society score (*10*) was used to evaluate fracture healing outcomes and were graded as excellent, good, fair or poor (*3*). Evaluation of donor site morbidity between the two groups and other complications of graft harvest were performed at the serial follow ups.

Table I. — Patient Demographics

Patient number	Age at ORIF (years)	Side	Sex	Time to ORIF (days)	Schatzker Fracture Type	Fracture Open/ closed	Associated Injuries	ORIF Technique
ICBG Group (n=16)								
1	39	L	M	5	II	Closed	Head Injury	Proximal lateral tibial plate
2	59	R	M	13	V	Closed	Bennett's # left	Posteromedial plate + Proximal lateral tibial plate
3	42	L	M	10	II	Closed	Fibular head #	Proximal lateral tibial plate
4	33	R	M	1	II	Grade 1	Fibular Neck #	Proximal lateral tibial plate
5	69	R	F	2	V	Closed	Nil	Lateral cancellous screw + Posteromedial plate
6	35	R	F	11	V	Closed	Head Injury	Posteromedial plate + Proximal lateral tibial plate
7	39	L	F	2	II	Closed	Lateral meniscus tear	Proximal lateral tibial plate
8	68	R	M	3	V	Grade 1	ACL rupture + Olecranon #	Lateral cancellous screw + Posteromedial plate
9	37	L	F	4	II	Closed	Nil	Proximal lateral tibial plate
10	41	R	F	1	II	Closed	Nil	Proximal lateral tibial plate
11	40	L	F	12	V	Closed	Distal radius # right	Posteromedial plate + Proximal lateral tibial plate
12	70	L	M	1	V	Closed	ACL rupture	Posteromedial plate + Proximal lateral tibial plate
13	29	R	M	9	VI	Closed	Nil	Posteromedial plate + Proximal lateral tibial plate
14	21	R	M	1	II	Grade 1	Lisfranc's right foot	Proximal lateral tibial plate
15	32	R	M	1	II	Closed	Nil	Proximal lateral tibial plate
16	34	L	M	1	II	Closed	Nil	Proximal lateral tibial plate
PTBG Group (n=18)								
1	56	R	F	11	V	Closed	Nil	Posteromedial plate + Proximal lateral tibial plate
2	38	R	M	12	VI	Closed	Fibular head #	Posteromedial plate + Proximal lateral tibial plate
3	54	L	M	1	II	Closed	Fibular Neck #	Proximal lateral tibial plate
4	43	L	M	3	II	Closed	Nil	Proximal lateral tibial plate
5	46	R	F	10	V	Closed	Distal radius # right	Lateral cancellous screw + Posteromedial plate
6	42	L	F	13	V	Closed	ACL rupture	Posteromedial plate + Proximal lateral tibial plate
7	28	R	M	4	II	Grade 1	Head Injury	Proximal lateral tibial plate
8	34	L	M	2	II	Closed	Fibular Neck #	Proximal lateral tibial plate
9	65	L	M	3	III	Closed	Nil	Lateral cancellous screw
10	29	R	M	1	II	Closed	Nil	Proximal lateral tibial plate
11	32	R	F	1	II	Closed	Nil	Proximal lateral tibial plate
12	76	L	F	10	V	Grade 1	ACL rupture + Lateral meniscus tear	Posteromedial plate + Proximal lateral tibial plate
13	44	R	M	1	II	Closed	Forearm fracture right	Proximal lateral tibial plate
14	52	L	F	1	II	Closed	Nil	Proximal lateral tibial plate
15	22	L	M	1	II	Closed	Nil	Proximal lateral tibial plate
16	77	R	M	1	V	Closed	Anterior dislocation left shoulder	Posteromedial plate + Proximal lateral tibial plate
17	26	R	M	3	II	Closed	Nil	Proximal lateral tibial plate
18	69	L	F	2	V	Closed	ACL rupture	Posteromedial plate + Proximal lateral tibial plate

Table II. —Complications and Outcomes

Patient No	Follow-up months	Time to fracture healing (weeks)	Fracture Complication	Donor Morbidity	VAS score	Knee score	Functional score	Grade
PTBG Group (n=18)								
1	12	14	Nil	Nil	6	93	100	Excellent
2	14	16	Nil	Nil	6	49	55	Poor
3	20	14	Nil	Nil	8	85	90	Excellent
4	30	12	Nil	Nil	7	93	90	Excellent
5	26	16	Wound Infection	Nil	6	86	65	Excellent
6	37	15	Nil	Chronic Pain	7	90	90	Excellent
7	28	13	Nil	Nil	7	84	90	Excellent
8	26	15	ACL Laxity	Abdominal Hernia	7	77	65	Good
9	30	13	Nil	Nil	6	88	90	Excellent
10	14	12	Nil	Nil	7	81	80	Excellent
11	32	16	Nil	Chronic Pain	6	78	80	Good
12	16	16	ACL Laxity	Nil	5	59	65	Poor
13	30	15	Nil	Chronic Pain	6	69	80	Fair
14	22	14	Nil	Nil	6	90	90	Excellent
15	24	12	Nil	Nil	9	93	100	Excellent
16	30	12	Nil	Infection	7	90	90	Excellent
PTBG Group (n=18)								
1	22	15	Wound Infection	Nil	6	74	65	Good
2	20	16	Nil	Nil	3	93	90	Excellent
3	18	14	Nil	Nil	4	93	100	Excellent
4	16	11	Nil	Nil	4	85	90	Excellent
5	24	15	Nil	Nil	3	65	65	Fair
6	12	15	ACL Laxity	Nil	2	78	80	Good
7	30	12	Nil	Nil	4	86	90	Excellent
8	34	12	Nil	Nil	5	90	90	Excellent
9	18	12	Nil	Nil	6	84	80	Excellent
10	36	14	Nil	Nil	4	93	100	Excellent
11	30	11	Nil	Nil	4	88	90	Excellent
12	28	16	ACL Laxity	Infection	3	48	55	Poor
13	14	12	Nil	Nil	3	88	80	Excellent
14	18	11	Nil	Nil	4	93	90	Excellent
15	20	12	Nil	Nil	7	83	80	Excellent
16	16	15	Nil	Nil	3	81	75	Excellent
17	32	11	Nil	Nil	6	78	90	Good
18	34	16	ACL Laxity	Nil	3	67	80	Fair

RESULTS

There were no intra-operative complications with either technique of graft harvest. The mean follow-up of ICBG group was 24.4 months (range 12-37) and PTBG was 23.4 months (range 6-36). Fracture union was achieved in all patients at a mean period of 14.06 weeks (range 12-16) in ICBG group and 14.0 weeks (range 11-16) in PTBG group (p value 0.958, not significant). Table 2 depicts the complications and outcomes in both the groups.

The knee scores showed similar outcomes in both the groups (Table 2). There was no difference between the groups for graft incorporation at fracture site. No radiological evidence of secondary arthritis was noted in either group at the final follow up (Figure 3a & 3b).

The ICBG group showed higher visual analogue pain scores in the immediate post-op period, superficial wound infection in 1 (6%), hernia formation in 1 (6%) and chronic pain at donor site in 3 (19%) patients. The mean VAS in ICBG group was 6.62 (95% CI 6.11-7.13) and in the PTBG group was 4.11 (95% CI 3.43-4.79) ($p < 0.0001$). There was one superficial wound infection in PTBG group, but none of the patients needed any further surgical input.

DISCUSSION

Complications associated with PTBG include hematoma formation, infection, neurovascular injury, inadvertent joint perforation, donor-site fracture and gait disturbance (*14*). In majority of instances these were minor complications. O'Keeffe reported a rate of donor-site complications of 1.3% at a mean follow-up period of 20.4 months in 230 procedures (*15*). In a retrospective review, Alt et

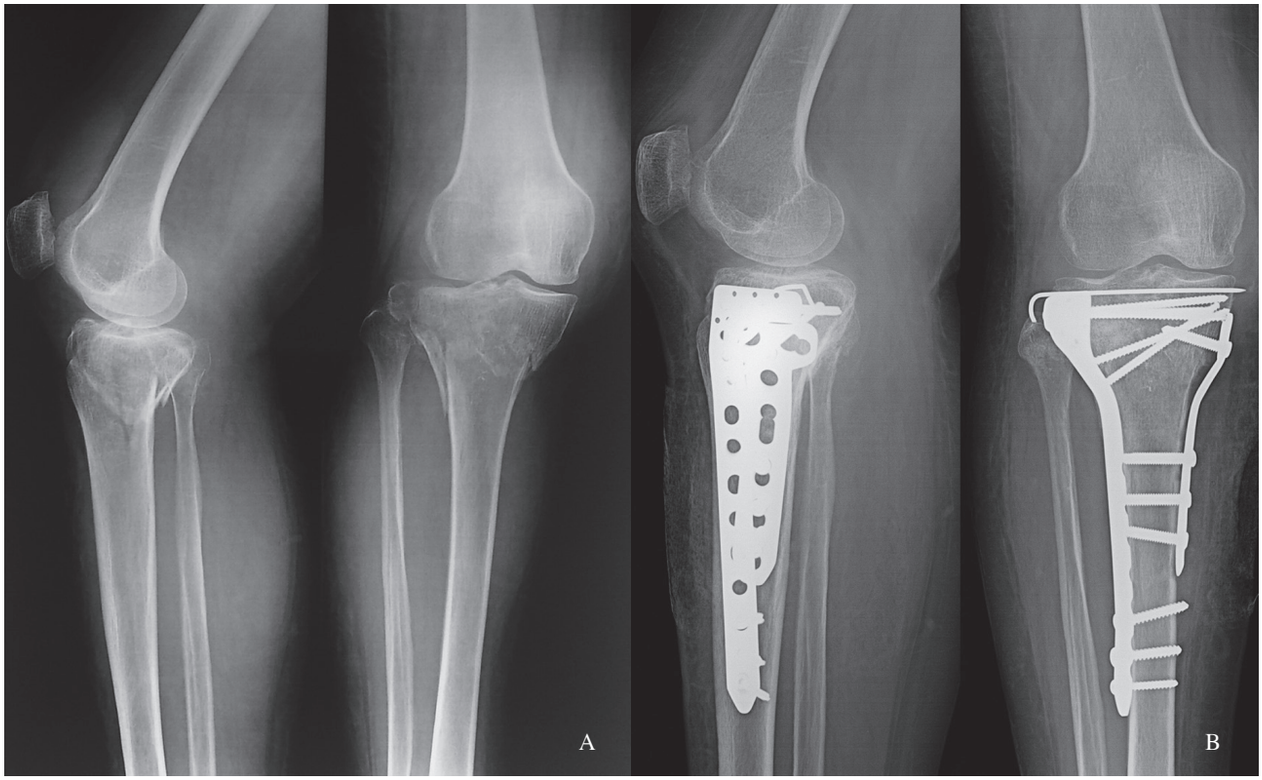

Fig. 3a & 3b. — Pre-operative and 12 month post-operative radiographs of dual plating of proximal tibia fracture in a 42 year old lady.

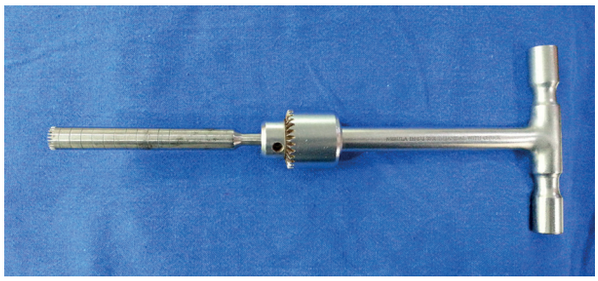

Fig. 4. — Hollow bone mill attached to the T-handle

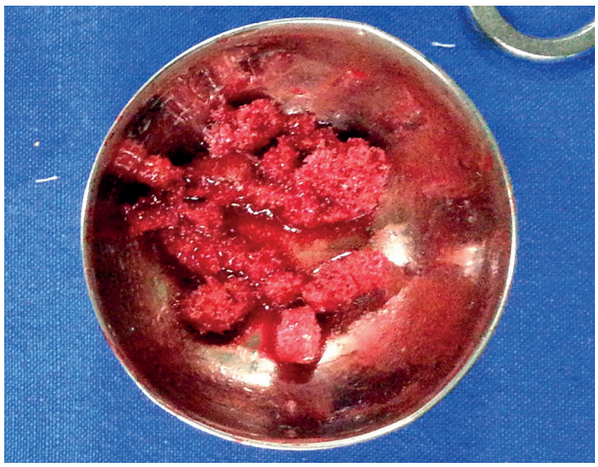

Fig. 5. — Volume of graft obtained

Fig. 6. — Leg positioned for fracture fixation and graft harvest

al. had an overall complication rate of 1.9% (local hematoma) at a mean 26 weeks follow-up in 54 patients (*2*).

Tibial fracture, a major complication of PTBG, is fortunately not common. Various factors including location of the harvest site, amount of decancellation of proximal tibia, shape of the cortical window, weight bearing status, post-operative activity levels have been implied in its causation (*7,11*). Care should be given not to advance the hollow mill or curette superiorly for the fear of breaching the articular surface. For the same reason, we start the cortical window slightly lower than the Gerdy's tubercle. Hand held hollow mill is gently advanced and the tactile feel obtained is a better judge of the distance travelled than the fluoroscopy radiographs. The tibia cross section makes it easy to penetrate the cortex if the advancement is based only on the fluoroscopy images. The aid of fluoroscopy may have a role in altered anatomy or in the presence of previous surgery around the knee to locate the direction of the graft to be harvested. We use a 13mm hollow bone mill and a large curette to obtain the graft (Figure 4).

The round edges of cortical window ensure minimal risk of crack propagation compared to a cube or liner margins with sharp corners. Other studies have shown similar techniques using a manual trephine with equally good outcomes (*9,12*).

Clinical and experimental studies have shown that unrestricted weight-bearing is not associated with increased risk of fractures (*1,2*). In-fact, our patients with PTBG mobilize weight- bearing only on the donor side as the recipient proximal tibial fracture side is allowed only touch weight-bearing. However we restrict any exercise or impact activities in our patients for 8-12 weeks post-operatively, as suggested by many other reports (*11,18*).

Our study showed adequate volume of graft harvested for the management of depressed tibial plateau fractures from the PTBG in all cases

No supplementary bone substitutes were required in any patient. The hollow mill can be advanced in different directions in the tibial metaphysis to obtain enough graft required for the metaphyseal bone voids. Mauffrey *et al* (*13*) showed that mean quantities of graft harvested was 6.2 cm^3 from the iliac crest compared to 7.3 cm^3 from the proximal tibia. They recommend that, due to reduced complications, PTBG be preferred when the location of the primary injury permits.

We have found that for proximal tibial fractures, the contralateral tibia is optimally positioned for

surgical prep and drape, and for obtaining the graft with minimal need to change the theatre set-up (Figure 6).

The patient position is supine or lateral with knee flexed depending on the fracture configuration to be dealt with. In the supine position, both the limbs are located ideally to harvest the graft and proceed with internal fixation. When it is essential to proceed with postero-lateral or postero-medial knee approach for fracture fixation, the graft is harvested first. We also have managed to harvest graft from the contralateral tibia with the patient in prone position, by flexing the donor side knee. The mean operating time to harvest the PTBG was 5.2 minutes (range 4-9 minutes).

The possible void in the proximal tibia acting as the donor site may be of concern to arthroplasty surgeons. There are reports to suggest that the tibial metaphyseal defect after bone harvest may be a permanent radiological finding (*15*). We do not have personal experience of performing knee arthroplasty in patients whose proximal tibia was the source of the autograft. However as this is a contained defect, unless there has been a complication like an intra-articular breach, the defect should not present a significant problem during knee replacement surgery. Use of impaction bone graft, structural bulk graft, cement filling, metal augments or custom made/hinged/endoprosthesis are the different options available to address the challenges of proximal tibial metaphyseal loss of bone stock during arthroplasty.

To our knowledge, this is the first report of PTBG for managing contralateral proximal tibia fractures. Previous reports of PTBG in the management of trauma were for a range of indications including acute trauma and non-union surgery (*15,16*). These reports mentioned graft use in tibial fractures but did not specify the type of fracture. Sferopoulos reported 18 depressed tibial plateau fractutes treated with autograft harvested from the ipsilateral distal femur (*17*). Average time to fracture union was 14 weeks and no donor site morbidity was reported. Translocation of the adjacent metaphyseal bone to the tibial plateau sub-chondral defect through the fracture flap as a technique has been reported (*5*). This avoided donor site morbidity while providing structural stability with supplementary plate fixation. Drawbacks of our study are the small number of patients, limited follow up period and lack of randomization to either group. However, we have conducted a comparative study between PTBG and ICBG sub-group of patients comparing the outcomes, complications and morbidity. The proximal tibial anatomy allows for simple surgical dissection and quick graft harvest that complements the operative fixation of contra lateral tibial plateau fractures. Patients tolerate the procedure and recover well.

In conclusion, the contralateral PTBG offers a viable alternative to ICBG as a donor site for bone graft in the management of unstable depressed tibial plateau fractures. Our study showed that the proximal tibia allows ease of surgical access, adequacy of graft quantity and quality, permits early rehabilitation; and is associated with minimal donor site morbidity.

ETHICAL STANDARD

(1) the patients have given the informed consent to being included into the study ; (2) the retrospective study was approved by the local ethical committee of the hospital and was performed in accordance with the Ethical standards of the 1964 Declaration of Helsinki as revised in 2000.

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