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ORIGINAL ARTICLE

Proximal Tibial Metaphysis: Its Reliability as a Donor Site for Grafting

Fiabilité de la Métaphyse tibiale proximale comme site de prélèvement de greffe osseuse

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ABSTRACT

BACKGROUND: **The iliac crest and the proximal tibial metaphysis are the commonest sites for harvesting bone grafts. However, obtaining bone grafts from these sites may be associated with significant morbidity.**

OBJECTIVE: **To study the pattern of complications encountered at each donor site and to determine the reliability of the proximal tibia as a donor site.**

METHODS: **This was a prospective study of all patients who had bone graft harvested from the iliac crest or the proximal tibia at the National Orthopaedic Hospital, Lagos between January 2006 and December 2006. All consecutive patients who were to undergo bone grafting were reviewed pre-operatively. Intra-operatively, the amount of blood loss and volume of graft harvested and the time taken to harvest it were noted. All intra-operative complications were also recorded. The immediate post-operative pain was assessed and any other complications at the donor sites were noted. They were followed up monthly in the outpatient clinic for six months.**

RESULTS: **A total of 74 patients were studied. The age range was 16–72 years with a mean of 39.7±12.3 years. The male:female ratio was 1.1:1. The commonest indication for cancellous bone graft was femoral fracture nonunion. Harvesting of iliac crest bone graft took a significantly longer time and was associated with more intra-operative blood loss and post-operative pain.**

CONCLUSION: **The commonest indication for cancellous bone graft is femoral fracture nonunion. Harvesting of bone graft from the proximal tibial metaphysis is associated with less morbidity than the iliac crest. WAJM 2010; 29(6): 403–407.**

Keywords: **Bone graft, proximal tibial metaphysis, donor site.**

RÉSUMÉ

CONTEXTE: *La crête iliaque et la métaphyse tibiale proximale sont les sites les plus communs pour les prélèvements de greffe osseuse. Néanmoins, ces prélèvements peuvent s'associer une morbidité significative.*

OBJECTIF: *Décrire les complications observées à chaque site, et déterminer la fiabilité de la métaphyse tibiale proximale comme site de prélèvement.*

MÉTHODES: *Il s'agissait d'une étude prospective intéressant tous les patients qui ont bénéficié d'une greffe osseuse dont le site de prélèvement était la crête iliaque ou la métaphyse tibiale proximale au niveau de l'hôpital national d'orthopédie de Lagos, entre janvier 2006 et décembre 2006.*

Tous les patients qui devaient bénéficier d'une greffe osseuse ont été vus en préopératoire. Durant l'opération, la quantité de sang perdu et le volume d'os prélevé, ainsi que le temps mis pour le prélèvement ont été notés. Toutes les complications opératoires ont été également enregistrées. La douleur postopératoire immédiate a été évaluée de même que toutes les autres complications aux site de prélèvement. Le suivi des patients a été poursuivi mensuellement dans la consultation externe pendant six mois.

RÉSULTATS: *Un total de 74 patients ont été enregistrés. L'âge moyen était de 39.7±12.3 ans avec des extrêmes de 16 et 72 ans. Le sex ratio était de 1,1 (H/F). L'indication la plus commune pour la greffe osseuse était la fracture fémorale complète. Le prélèvement au niveau de la crête iliaque a pris un temps sensiblement plus long et a été associé à un saignement opératoire plus abondant et une douleur postopératoire plus importante.*

CONCLUSION: *L'indication la plus commune pour la greffe osseuse est la fracture fémorale complète. Le prélèvement de la greffe osseuse de la métaphyse tibiale proximale est associé à moins de morbidité que la crête iliaque.* ***WAJM 2010; 29 (6): 403–407.***

Mots-clés: *greffe osseuse, métaphyse tibiale proximale, site de prélèvement.*

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INTRODUCTION

Bone graft is any implanted bone material that alone or in combination with other materials promotes a bone healing response by providing osteogenic, osteoconductive or osteoinductive activity to a local site.[1] Bone graft can be autogenous (derived from the same individual) or allogenous (from another individual of the same species).

Currently, autogenous bone grafting from a variety of donor sites, is the preferred treatment for a wide variety of orthopaedic conditions including difficult fractures, replacement of bone defects, treatment of nonunions and joint arthrodesis.[2,3] It is the gold standard because of its very high osteogenic, osteconductive and osteoinductive properties compared with allogenous bone graft.[3,4]

However, the acquisition of autogenous bone transplant materials is not accomplished without certain cost to the patient. These costs may include additional surgical incision with increased blood loss and trauma, increased surgical time, and increased post operative morbidity from pain and potential infection or deformity.[5,6,7] In addition there is sacrifice of normal structure, and weakening of donor bone[8–13] or risk of significant complications e.g. arterial and nerve injuries.[5,14–18]

The iliac crest is currently the most common donor site for obtaining autogenous bone for the purpose of grafting.[2,19,20] The ilium has been identified as an excellent source of both cortical and cancellous bone. Both the anterior and posterior portions of the iliac crest are often used for the purpose of bone grafting.[2] However, obtaining bone from the iliac crest can be associated with significant morbidity amongst which are arterial injury, chronic pain, nerve injury, infection, fracture, pelvic instability, cosmetic defect and haematoma.[2,3,6] Harvesting bone graft from the iliac crest has been reported to be associated with post-operative complication rate as high as 49%.[21,22]

The proximal tibia is an alternative donor site for cancellous bone,[23–25] associated with clinical post-operative complication rates less than 2%. However, the use of the proximal tibia for bone graft harvesting is not widely practiced. The reluctance to use the proximal tibia as a donor site for bone grafting is based on the lack of information regarding the volume of bone that can be harvested without increasing the risk of tibia fracture after the graft is taken.[23]

Autogenous cancellous bone graft is commonly harvested from the iliac crest as well as from the proximal tibia at the National Orthopaedic Hospital, Igbobi, Lagos. In order to compare donor site complications between the two donor sites and to determine the reliability of the proximal tibial metaphysis as a donor site, a prospective study on the indications and complications of iliac crest and proximal tibial donor site was carried out in this centre over a period of one year.

SUBJECTS, MATERIALS, AND METHODS

This was a prospective study of all patients who had cancellous bone graft harvested from either the iliac crest or the proximal tibial metaphysis at the National Orthopaedic Hospital, Igbobi, Lagos between January 1st 2006 and December 31st 2006. Approval was obtained from the hospital ethical committee before the commencement of the study.

The aims of the study were explained to the patients and consent obtained from them or where necessary from the parents/guardian. At the beginning of every week, we liaised with the Senior Registrar in each unit to find out the patients who were likely to have cancellous bone grafting as part of the definitive surgical procedure during the course of the week. These were usually confirmed as soon as the operation lists were out.

Pre-operative assessment of the patients was done and this included history-taking, thorough physical examination, and relevant investigations. Their pre-morbid status, history of previous bone grafting procedures history of pain (in the iliac crest, the hip, the thigh, the knee joint or the proximal tibia) were noted. Drug history as well as social history was recorded and pre-operative packed cell volume done.

Intra-operatively, the amount of graft harvested, the time taken to harvest the graft and the amount of blood loss were recorded. The amount of graft was quantified using packed volume analysis. The harvested cancellous bones were placed in a 10ml syringe and maximal thumb pressure on the plunger ensured packing of the graft. This packing allowed an analysis independent of geometry and inter-trabecular spaces of the graft and provided a reliable method of measurement. The time taken to harvest the graft was defined as the time interval between skin incision and closure at the graft site and this was done using a stopwatch. The blood loss was calculated by estimating that a fully soaked standard surgical gauze contained 15ml of blood. Any intra-operative complication including iatrogenic fractures or vascular injury was also recorded.

Post-operatively, the patients were seen daily on the ward and any hyperaemia or discharge around the donor site noted. Any further complications related to the donor site that arose were noted until the patients were discharged home. They were then followed up monthly in the outpatient clinic for a period of six months.

Pain at the incision site and adjacent areas was assessed at one and three months post-operatively on a modified visual analogue scale wherein a score of zero (0) was interpreted as no pain and ten (10) as maximum pain. Any deformity or fracture at the donor site was also noted. Patients' satisfaction with the site of bone graft was assessed; they were asked whether they would recommend the same procedure to others or not.

Technique for Removal of Anterior Iliac Crest Graft

The patient was placed supine on the operating table and the iliac crest draped as a separate unit. A small sandbag was placed under the gluteal area of the side from which the graft would be taken to elevate and internally rotate the crest, making it more accessible.

The most important landmark was the subcutaneous anterior superior iliac spine, which was easily palpable. Palpation was continued along the crest

of the ilium until the widest portion of the ilium, the iliac tubercle is reached. The iliac tubercle marks the anterior portion of the ilium, (the area containing the largest amount of cancellous bone for graft material).

A 4-6cm incision was made parallel to the iliac crest and centred over the iliac tubercle. The skin was retracted and the iliac crest identified. The crest was then incised and the origins of the gluteus medius and minimus muscles detached subperiosteally from the outer cortex with periosteal elevators to expose bare bone. An osteotome was then used to create an opening on the crest and the cancellous bone scooped out with a big curette. The wound was irrigated with normal saline and closed back in layers.

Technique for Removal of Proximal Tibial Graft

The patient was placed supine on the operating table. The leg was prepared and draped separately. A slightly curved longitudinal incision was made over the anteromedial surface of the proximal tibia. Without reflecting the skin, the periosteum was incised to the bone. With a periosteal elevator, the periosteum was reflected medially and laterally, exposing the surface of the tibia between the anterior and the medial borders of the tibia. A sharp osteotome was then used to create an oval shaped window on the cortex through which the cancellous bone was scooped out with a large curette. The wound was irrigated with normal saline, the periosteum apposed and the wound closed.

Statistical Analysis

The data were recorded in a designated proforma and analyzed using statistical package for social sciences (SPSS) version 12. The test of significant association was done using Chi square or Fisher exact test where appropriate and the level of significance set at $p < 0.05$.

RESULTS

A total of seventy-four patients were recruited into the study. Eight patients had cancellous bone graft harvested from two different sites; three of them at the same surgery, while five were at different surgeries. The remainder had bone graft harvested at only one site giving a total of 82 procedures.

The age range was between 16 and 72 years with a mean age of 39.7 ± 12.3 years. Majority (77%) of them were between 21 and 50 years of age. Only one (1.2%) patient was > 70years old, (Table 1). There were 39 (52.7%) male patients and 35 (47.3%) female patients with a male: female ratio of 1.1:1. Seven (8.5%) patients were hypertensive while 4 (4.9%) were diabetic and 71 (86.6%) were neither diabetic nor hypertensive.

The commonest indication for cancellous bone grafting was femoral fracture nonunion in 30 (36.6%) patients followed by humeral fracture nonunion in 15 (18.3%) patients and femoral fractures in 13 (15.9%) patients. The other indications are as shown in Table 2. The most common donor site used for harvesting cancellous bone graft was the proximal tibial metaphysis. The proximal tibia was the donor site in 56 (68.3%) procedures, while the anterior iliac crest was used in 26 (31.7%) procedures. The posterior iliac crest was not used at all.

The average time to harvest graft from the iliac crest was 25.8mins while that of the tibia was 18.7mins. ($\chi^2 = 8.17$; $p < 0.05$). The average volume of graft that was harvested from the iliac crest was 7.3cm^3, while that from the tibia was 8.6cm^3. ($\chi^2 = 0.07$; $p > 0.05$). The average blood loss from the iliac crest following cancellous bone graft harvesting was 42.3cm^3, while that from the proximal tibia was 26.3cm^3. ($\chi^2 = 13.55$; $p < 0.05$). There were only two cases of superficial soft tissue infection following bone grafting from the tibia, giving an infection rate of 3.6 %. The aspirated pus from both cases grew no organisms and both responded to a course of antibiotics without any need for a wound debridement. Neither of these two patients was diabetic. No wound infection occurred at the iliac crest.

The average severity of pain at one month using the modified visual analogue scale for the iliac crest was 4.8, while that for the tibia was 2.3, (Table 3). ($\chi^2 = 4.48$; $p < 0.05$). The average severity of pain at three months using the modified visual analogue scale for the iliac crest was 1.6, while that for the tibia was 1.1, (Table 3). ($\chi^2 = 1.6$; Fisher exact $p > 0.05$).

In the proximal tibial group, 53 (94.64%) were very satisfied with the procedure; 1 (1.79%) was just satisfied while 2 (3.5%) were not satisfied. In the iliac crest group, 8 (30.77%) were satisfied, 15 (57.69%) were just satisfied while 3 (11.54%) were not satisfied. ($\chi^2 = 4.33$; Fisher exact $p < 0.05$). Fifty-two (93%) of those in the tibial group would recommend the procedure to others while 2 (3.5%) would not and another 2 (3.5%) were indifferent. In the iliac group, 18 (69.23%) would recommend the procedure to others, while 3 (11.54%) would not and 5 (19.23%) were indifferent. ($\chi^2 = 1.29$; Fisher exact $p > 0.05$).

Table 1: Distribution of Participants by Age

Age (Years)	Number	(%)
11 – 20	3	3.6
21 – 30	18	21.9
31 – 40	25	30.5
41 – 50	20	24.6
51 – 60	11	13.4
61 – 70	4	4.8
71 – 80	1	1.2
Total	**82**	**100.0**

Table 2: Indications for Bone Grafting

Diagnosis		Number(%)
Ankle fracture	2	2.4
Fracture femur	13	15.9
Fracture humerus	2	2.4
Fracture metacarpal	1	1.2
Fracture radius	1	1.2
Talar fracture	1	1.2
Fracture tibia	3	3.7
Blount's disease	1	1.2
Chronic osteomyelitis (tibia)	1	1.2
Delayed union humerus	1	1.2
Giant cell tumour radius	1	1.2
Giant cell tumour ulna	1	1.2
Malunion femur	2	2.4
Malunion humerus	1	1.2
Malunion tibia	1	1.2
Nonunion femur	30	36.6
Nonunion humerus	15	18.3
Nonunion radius/ulna	2	2.4
Nonunion radius	1	1.2
Nonunion tibia	2	2.4
Total	**82**	**100.0**

DISCUSSION

A total of 74 patients who underwent 82 cancellous bone graft harvesting procedures were studied over a period

Table 3: Distribution of Subjects by Severity of Pain at One and Three Months

Severity of Pain	Number	
	One Month	Three Months
Iliac Crest (No. of Patients		
1.	1	14
2.	1	9
3.	2	2
4.	6	1
5.	5	0
6.	11	0
Total	**26**	**26**
Tibia (No. of Patients)		
1.	20	52
2.	17	4
3.	8	–
4.	6	–
5.	3	–
6.	2	–
Total	**56**	**56**

of one year. The age incidence showed that majority of the patients were between 21 and 50 years, (the economically active age group). The sex incidence showed a slight male preponderance.

In this study, the more common donor site used for harvesting cancellous bone graft was the proximal tibial metaphysis (68.3%). This is contrary to earlier reports by Seller and Johnson,[2] Arrington *et al,*[19] and Fowler *et al*[20] who all reported that the commonest site for autogenous bone graft was the iliac crest. However, both sites contain adequate amount of cancellous bone. Alt *et al,*[23] in his experimental study on human cadaver tibiae reported that the average volume of bone that can be harvested from the proximal tibia was 5.4cm^3 compared with a reported volume of 6cm^3 from the iliac crest. In this study, the average volume of graft that was harvested from the iliac crest was 7.3cm^3, while that from the proximal tibia was 8.6cm^3 showing no statistically significant difference. This is comparable with the reports by Alt *et al*[23] and shows that adequate amount of graft can be taken from the two sites.

The commonest indication for cancellous bone grafting was femoral fracture nonunion followed by humeral fracture nonunion and then fresh femoral fractures. Other indications varied from treatment of fractures and nonunions in other long bones to chronic osteomyelitis, tumours and metacarpal fractures. This shows the versatility of the use of cancellous bone graft.[3]

There was a statistically significant difference in the duration of graft harvesting procedure between the two sites showing that a significant amount of time is added on to the operation time during iliac crest bone graft harvesting. The results also show that there is significantly more blood loss from the iliac crest during cancellous bone graft harvesting, than from the tibial site.

The infection rate of 3.6% (2/56) found in patients in the tibial group was insignificant as the infections in the two cases were located in the superficial soft tissues and both responded to a course of antibiotics only. Post-operative pain at one month was statistically more significant in the iliac crest group compared with the tibial group. However, there was no statistically significant difference in the degree of post-operative pain felt at three months by both groups in this study. We can deduce from these that harvesting bone graft from the proximal tibia has less morbidity than from the iliac crest with regards to post-operative pain at one month.

The patients in the proximal tibia group were more satisfied with the procedure than patients in the iliac crest group. This may be the reason they would recommend the procedure to others. However, what is more important in determining the superiority of one site over the other is the osteogenic and osteoinductive potential of the graft. To determine this, a controlled study that would follow up the patients to the end point (i.e union) is required.

Conclusion

The iliac crest donor site is associated with a significantly increased operative time and intra-operative blood loss and more post-operative pain than the proximal tibial site. Adequate amount of graft can be harvested from the proximal tibial metaphysis and the iliac crest. The proximal tibial metaphysis is a good source of autogenous bone graft associated with minimal intra- and post-operative morbidity and is therefore a reliable site for harvesting bone graft.

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Duality of Interest

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