



Research Article

Donor Site Morbidity Associated with Cancellous Bone Harvest from the Anterior Iliac Crest: Using a Mini-Access Approach and Literature Review

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Abstract:

Introduction: The anterior iliac crest is a popular donor sites for cancellous bone in alveolar cleft reconstruction. Potential problems such as donor site pain, restricted ambulation, and sensory nerve injury, are common drawbacks. We developed a mini-access approach to harvest cancellous bone graft from the iliac crest and reviewed the donor site morbidity in the literature.

Methods: We reviewed the previously-collected data from patients who underwent alveolar bone grafting using the mini-access approach from the iliac crest in 2005, which was the second year in which we used this method. Donor site morbidity was recorded and analyzed. Data from a total of 40 patients were reviewed.

Results: 28 patients were male and 12 were female with a mean age of 10. Thirty-three patients had a unilateral cleft, and 7 patients had bilateral clefts. The average bone graft volume was 5.35 ml, while the average length of hospitalization was 4.55 days. Suspected lateral femoral cutaneous nerve injury occurred in 10% of the cases.

Conclusion: Compared to the literature, although we could not conclude that the mini-access approach is absolutely better than the other methods, it provides an easy, alternative way without special equipments to decrease the donor site morbidity.

Keywords: cancellous bone graft, iliac crest, donor site morbidity

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Introduction

Reconstructing alveolar defects in cleft patients requires a cancellous bone graft. Many possible donor sites have been described, including the costal bone, tibia, mandibular symphysis, calvarial bone, and iliac crest [1-4]. The iliac crest has been the most popular source of cancellous bone graft due to its abundance of graft, ease of harvest, favorable bone quality and the possibility of using a simultaneous two-team approach. The traditional open approach described by Wolfe *et al* required a 5-cm incision and split osteotomy of the iliac crest [5]. Potential problems with this approach include significant postoperative donor site pain and a higher risk of damage to the lateral femoral cutaneous nerve. These problems further lead to limited ambulation and prolonged recovery time. To minimize these complications, our unit developed a mini-access approach which was modified from the open method, for harvesting iliac bone graft.

Material and Methods

We reviewed the previously-collected data from all patients who underwent alveolar bone grafting surgery with a harvest of cancellous bone graft from the iliac crest in 2005. It was the second year in which we used the mini-access approach to harvest bone grafts. All patients received oral ibuprofen and intramuscular ketoralac for pain control and identical wound dressings postoperatively. To assess outcomes, details were collected on postoperative donor site pain, time to ambulation, suspected lateral femoral cutaneous nerve injury and days of hospitalization. Patients reported the severity of their pain using an established visual analog scale for pediatric patients, the Wong-Baker FACES Pain Rating scale (Fig. 1). The Internal Review Board (IRB) was applied and permission was obtained.

Patient Data: Name: _____ Age: _____ Registration No.: _____

Circle the correct response: Cleft Alveolus: Bilateral
Unilateral: Left / Right

Alveolar Bone Graft Surgery Questionnaire 2005
Donor Site Pain Estimate Diagram

FACES Pain Rating Scale

1. Using the above Pain Rating Scale for pain score, please circle the most appropriate response from 0 to 5 for **donor site** pain:

Pain Score (Hip Area)	After Surgery (2 hours after reaching ward)	24 Hours After Surgery (First Day)	48 Hours After Surgery (Second Day)
Resting in Bed	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
Walking	Yes / No	Yes / No	Yes / No
	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
Feeding	Poor/Average/Good	Poor/Average/Good	Poor/Average/Good
Intravenous Fluid	+ / -	+ / -	+ / -

For example:

Pain Score (Hip Area)	After Surgery
Resting in Bed	0 1 2 3 4 5

2. Numbness in the area outside of the knee cap?: Yes / No (Please Circle)

Please submit the completed form to the nursing staff in charge.

Figure 1 Patient questionnaire for pain scoring after cancellous bone graft procedure

Operative technique

A 1- to 1.5- cm incision was made on the thickest portion of the iliac crest, posterior to the anterior superior iliac spine (ASIS). Upon breaching the skin and subcutaneous tissue, retraction was achieved using a pair of double-pronged skin hooks to expose the iliac periosteum. A mallet and a set of straight and curved mini Lambotte osteotomes were then used to carefully chisel a laterally-based cortical bone flap. Muscle attachments to the iliac crest were carefully preserved to minimize pain and injury to the nerves. The outer bridge of the periosteum and cortex were retained as the “hinge” of the trapdoor, to allow bony union and to preserve the contour of the iliac crest. The trapdoor was swung open to allow access into the medullary cavity, where cancellous bone can be harvested under direct visualization using bone curettes. After harvesting an adequate volume of graft material, the bone window was closed by repositioning the small bone flap. In most cases, PDS sutures were sufficient to achieve a hemostatic closure. Theoretically, the graft could be harvested from a fan-shaped area on the iliac bone (A). The volume of the fan was calculated as $nh \pi r^2/360$ (n: the angle of the fan, r: the radius of the fan, h: height of medullary cavity of iliac bone) (Fig. 2).

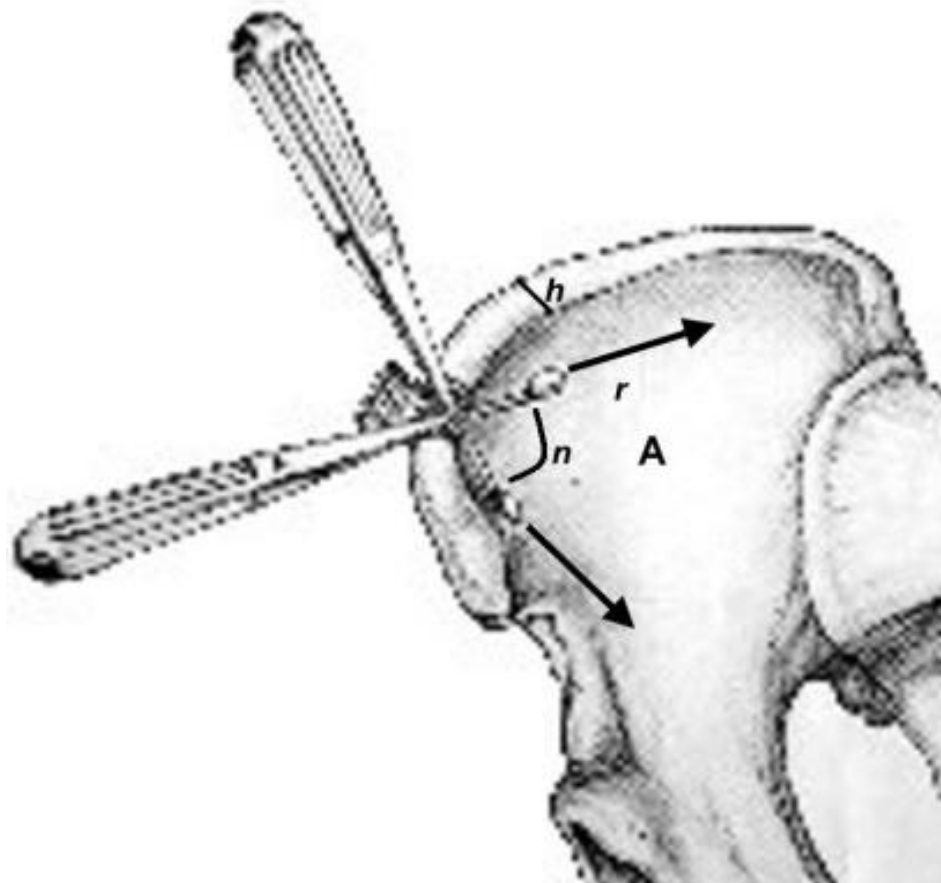


Figure 2 The illustration of mini-access approach and the area of bone graft which could be harvested. (A: fan-shaped area in which curettes could move without disrupting cortex; n: the angle of the fan, r: the radius of the fan, h: height of medullary cavity of iliac bone)

Results

Forty patients were included in this study. Twenty-eight of the patients were male, and 12 were female. All patients had alveolar clefts, including 33 unilateral clefts and 7 bilateral clefts. Their ages ranged from 8 to 15 years with an average age of 10 years. The average graft volume obtained was 5.35ml on average (range: 2 to 10ml). (Table 1) All patients started ambulating by 2 hours postoperatively, and the average pain scores were reported as 2.95 and 2.36 for those receiving bed-rest and ambulating, respectively. The pain scores declined to 2.30 and 1.68, respectively, at 24 hours postoperatively and were significantly reduced by 48 hours, when the pain scores for bed-rest and ambulation were at 1.53 and 1.33, respectively (Fig. 3). The length of hospitalization varied from 3 to 6 days, with a mean of 4.55 days. Four patients reported lateral thigh numbness in the postoperative period (10%), but all numbness sensations resolved upon assessment during outpatient follow-up. No complications due to hematomas were observed within the studied population.

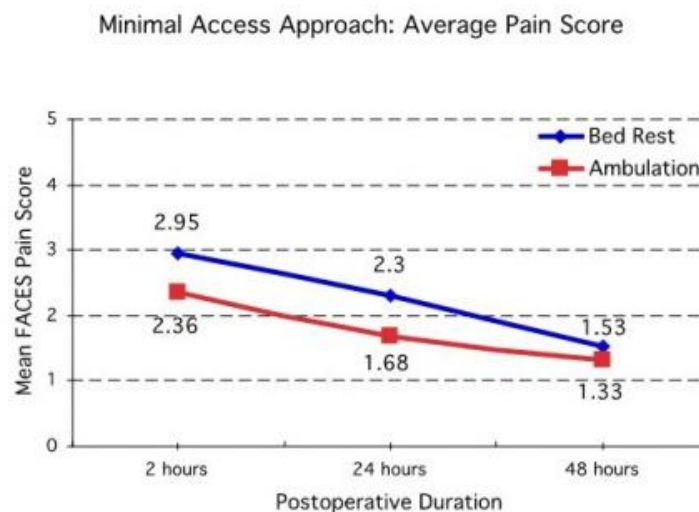


Figure 3 Mean recorded pain score for patients using the Wong-Baker FACES Pain Rating Scale

Discussion

Cancellous bone graft to reconstruct alveolar clefts has been widely used, and the best results are obtained when it is performed prior to the eruption of permanent canines [6, 7]. Although various donor sites for cancellous bone have been described, the iliac crest remains the most ideal site, because it has favorable bone quality, abundant graft material, easy access, lack of growth disturbances, re-harvest potential, and reduced operating time because it allows two teams to simultaneously harvest and prepare the alveolar cleft site [8]. Nevertheless, postoperative complications were still reported, with pain at the hip region being most frequently reported, while a fracture of the iliac crest is the most severe local complication. In an attempt to prevent the complications associated with long incisions and an osteotomy, several harvest techniques have been described, including trephination and specialized osteotomes.

Traditional open method

Wolfe *et al* described the open method for harvesting iliac cortico-cancellous graft, developed during their training with Paul Tessier. The incision that they described was five centimeters long [5]. The cortico-cancellous graft was obtained by splitting the iliac crest from the outer ridge with an oblique osteotome. The graft could be harvested from the iliac crest as a cortico-cancellous block after reflecting the periosteum. If only cancellous bone was required, the iliac bone cortices were split without reflecting the periosteum, and the central block of cancellous bone was harvested as graft. The two split iliac crest fragments were then sutured with wire. To minimize morbidity, the trapdoor modification was described for pure cancellous bone harvest [9], in which only a segment of the anterior iliac crest was partially elevated, while a bridge of periosteum was preserved as the “hinge” of the iliac crest trapdoor. The trapdoor was then opened and cancellous bone was harvested by curettage. Although the skin incision was shorter than the traditional open method, an incision with minimal length of 2- to 3- cm would be required to allow access to the self-retaining retractor. Additionally, the large bone window still caused postoperative pain and the possibility of a sensory disturbance in the lateral thigh.

Trephine method

Caddy *et al* described the technique of harvesting an iliac cancellous bone graft using a bone biopsy set to trephine cores of cancellous bone [10]. Thaller *et al* also described a similar method [11]. Both reported significant reduction in donor site morbidities. Sharma *et al* also published a minimally invasive technique that used a trephine system, and they concluded that this method had lower morbidity rates than the conventional open method [12]. The special equipment was needed when using this trephine method.

Open method with cylinder osteotome

Shepard *et al* described a cylinder osteotome designed to harvest iliac cancellous bone grafts [13]. Shepard’s cylinder osteotome method was used to solve a problem in the trephination method, whereby bone grafts were frequently retained or fragmented on withdrawal of the devices. A set of luminal tines within the cylinder allowed clean fractures of the cores at the end of the osteotome upon twisting, thus allowing the retrieval of the entire core. Schaaf *et al* reported the donor site morbidity of Shepard’s device and compared it with the circular saw method of harvesting cortico-cancellous iliac graft [14]. Compared to the traditional open method, this method is less invasive. However, special equipment, the cylinder osteotome, is still necessary.

Graft volume

Canady *et al* and Rudman both reported an average yield of 4.1ml of cancellous bone, and a maximum of 9.2ml when using the traditional open method [15,16]. This result is similar to the average of 4.47ml harvested using the Shepard cylinder osteotome, reported by Constantinides [17]. Based on our practice, the graft could be harvested deep to 5 cm in the iliac bone without disrupting the bone cortex (maximum d= 5 cm). The maximal angle of the curettage movement was about 100o (maximum n= 100) while the height of medullary cavity was about 0.6 cm (h=1). Therefore the maximal volume of graft that could be harvested by our technique was about 13ml theoretically. The result revealed an average of 5.35ml and the most volume was 10ml (Fig. 4, Patient 31).

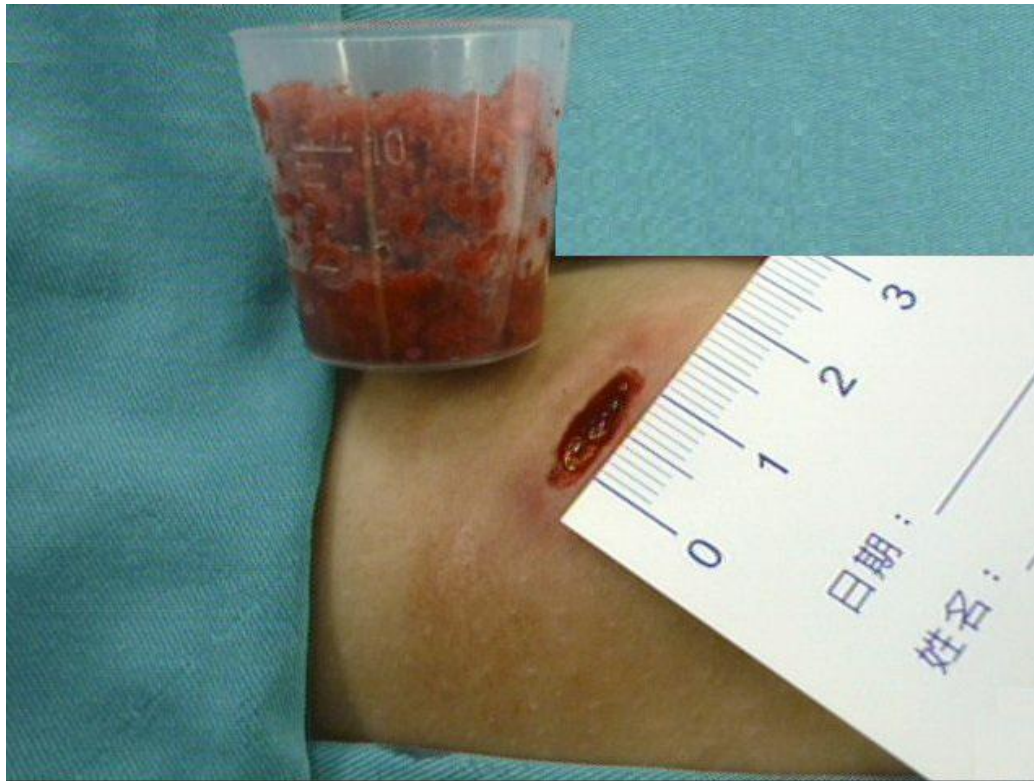


Figure 4 Typical volume of cancellous bone harvested using the mini-access approach (patient 31)

Wound length

A 5- cm incision was used in the traditional method described by Wolfe *et al.*[5] Rudman prospectively evaluated the harvest of iliac cancellous bone using the trapdoor modification of the traditional method, and reported that the incision required an average length of 2.9cm [16]. Although Scott *et al* used the trephine curettage method of harvest of iliac bone graft by creating a 2.5- cm incision for access [18], the smallest scar reported when using this method was approximately 1 to 1.5 cm long, as described in two reports by Caddy *et al.*[10] and Thaller *et al.* [11] The other “closed” method pioneered by Shepard using the cylinder osteotome similarly required an incision with a length of 2cm [13]. This mini-access technique required an 1- to 1.5- cm incision to yield adequate graft material.

Pain

Canady *et al* reported that 45% of patients suffered from moderate pain and that 22% described severe pain in the immediate postoperative period after cancellous bone graft harvest using the traditional open method [15]. However, Dawson *et al* concluded that pain was not severe and was easily alleviated by small amounts of analgesia following, the traditional open method of cancellous bone harvest from the iliac crest [19]. Eufinger *et al* compared the cylinder osteotome with the traditional open method and concluded that more analgesics were used in the traditional open group [20]. More recently, Sharma *et al* compared trephination with the traditional open method and reported that patients in the trephination group had a lower pain score than those in the traditional open method [12]. Barone *et al* reported a ten-year analysis, showing that 99% of the 235 patients studied complained of pain at the donor site 1 week after intervention, although this percentage was significantly reduced at 5 weeks. Barone *et al* used a similar visual analog

scale, ranging from 0 to 10, which is more frequently used for adults [21]. Using the 10-point scale, the mean pain score was 5.5 at one week postoperatively, or slightly higher than the median. Our patients reported pain scales of a mean of 2.36 out of 5, at 2 hours after surgery. More significantly, the pain had subsided significantly at 2 days postoperatively, with an average reported pain score of 1.33. In our population, most patients reported lower pain scores during ambulation compared to bed-rest within the same postoperative period. Presumably, the activities in which a child engages while ambulating serve as a distraction and reduce pain perception. In addition, the mini-access technique prevents injury to the attachments of the oblique and transversalis abdominal wall muscles by minimizing the incision used. We think this is the reason to cause less painful ambulation after surgery.

Postoperative ambulation

Measuring functional morbidity presents significant challenges due to its subjective nature and the lack of a standardized measure for patients after bone graft harvest. Time to ambulation is generally one measured outcome, but it is influenced by analgesic use, patient and provider attitudes and hospital protocol. Canady *et al* assessed the suitability of the iliac crest as a donor site, using data from 44 patients who responded to questionnaires following cancellous bone harvest procedures using the traditional open method. Although the majority of his patients reported limping up to 4 weeks after surgery, 95% of respondents reported being able to walk to the toilet within 24 hours of surgery [15]. Rudman reported that it took his patients an average of 3 hours and 18 minutes to start ambulating after the traditional open method of harvest [16]. Sandor *et al* concluded that patients who accepted the trephine method ambulated without assistance more quickly than the traditional method group [22]. Using the Shepard cylinder osteotome, Schaaf *et al* reported functional impairment among 64% of patients, with 4% of the patients having a persistent functional disorder, such as decreased strength when walking or climbing stair [14]. In our study, all patients started ambulating within two hours postoperatively, and by 48 hours, all patients were ambulating without assistance.

Sensory disturbance

Reports of sensory disturbance vary greatly. Canady *et al* reported numbness in 7% of patients who underwent the traditional open method [15]. Baqain *et al* reported neuropraxia of the lateral femoral cutaneous nerve in 2 of 24 patients (8.3%) undergoing the traditional open method of cancellous bone harvest [23]. This result is in contrast with a 52.3% sensory disturbance rate in the first post-operative week reported by Barone *et al*, although all cases resolved eventually [21]. Using the cylinder osteotome method, Schaaf *et al* reported that 22.7% of patients had a sensory disturbance of the lateral thigh [14]. In our series, 10% of patients reported a sensory disturbance of the lateral thigh, but all gradually recovered during the follow-up assessment.

Limitation of the study

Lacking a control group is the weak point of this study. Although this study would benefit from an objective comparison with a control group to allow for statistical comparison, such a design is frequently difficult in light of ethical considerations, as most patients would hesitate to agree to a longer scar without a significant advantage over a short scar. Since 2004, we have used this on more than 300 patients and the traditional open method has been discarded, which makes it impossible to collect a control group. However, the patients who underwent the mini-access procedure did recover faster by our clinical observation. Although we tried to compare our data to the literature, most of them did not provide enough evidence for comparison and wide variability existed in techniques, patient groups, etc. Therefore, we could only draw the conclusion that the mini-access approach could be an alternative way to harvest iliac bone graft to decrease donor site morbidity without any special equipment, which is necessary for trephine and open method with

cylinder osteotome. A summary of the literature review is shown on Table 2.

In conclusion, we described a mini-access approach to harvest cancellous bone grafts for alveolar cleft reconstruction using routine instruments. Apart from the disadvantage of a short learning curve, this technique has the benefits of a short scar, as in the closed or minimally invasive approach, though it does not require specialized osteotomes, and it offers the advantage of using the open trapdoor technique in preserving the iliac crest contour. Although we are unable to conclude whether this method is superior to the previous method in the literature, this method provides an alternative way to harvest iliac bone graft to decrease donor site morbidity.

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Table 1. Patient demographics

Patient	Age(y/r)	Gender	Cleft	Volume(G)	S :B/A(2hour)	S :B/A(24hour)	S :B/A(48hour)	Numb	Stay(day)
1	14	F	L	5ml	4/1	3/0	3/1	No	4
2	8	M	L	4ml	1/1	2/2	2/2	No	6
3	10	F	R	5ml	3/3	3/2	2/2	No	5
4	10	M	R	5ml	5/4	4/3	3/3	No	4
5	9	M	L	5ml	3/3	2/2	0/2	No	5
6	10	F	Bill	8ml	4/4	4/4	3/3	No	5
7	12	F	L	5ml	3/3	1/1	0/1	No	4
8	11	M	R	4ml	3/3	1/1	1/1	No	5
9	10	F	Bill	6ml	3/0	2/0	1/0	No	4
10	8	M	R	4ml	5/4	4/2	0/0	No	5
11	15	M	L	6ml	2/3	1/1	1/1	No	4
12	12	M	L	2ml	2/2	1/1	1/0	No	3
13	8	F	L	5ml	3/3	3/2	3/2	No	5
14	9	F	R	5ml	4/2	3/2	3/1	Yes	5
15	11	M	Bill	6ml	1/1	1/1	0/1	Yes	5
16	11	M	L	4ml	2/2	2/1	1/1	Yes	5
17	9	M	R	5ml	3/1	4/1	2/2	No	5
18	9	M	L	5ml	4/2	3/2	1/1	No	5
19	8	M	R	3ml	3/2	3/2	0/1	No	4
20	10	M	L	4ml	1/1	0/1	1/1	No	5

Abbreviation: Volume(G), Volume of graft; S, Pain score; B, Bed-rest; A, Ambulation; Stay, length of hospital stay

Table 1. Patient demographics (continue)

Patient	Age(y/r)	Gender	Cleft	Volume(G)	S :B/A(2hour)	S :B/A(24hour)	S :B/A(48hour)	Numb	Stay(day)
21	9	M	R	5ml	1/0	2/2	2/1	No	4
22	9	M	L	6ml	5/5	1/1	1/0	No	4
23	8	M	L	6ml	3/1	3/1	4/1	No	4
24	15	M	Bill	7ml	3/2	2/2	1/1	No	4
25	12	F	L	5ml	5/5	4/4	3/3	No	5
26	10	M	L	5ml	0/0	0/0	0/0	No	4
27	12	M	R	5ml	3/2	1/1	0/1	No	4
28	10	M	L	8ml	3/5	3/3	2/2	No	4
29	9	F	L	6ml	3/3	2/2	2/2	No	5
30	10	M	Bill	8ml	3/2	2/2	1/1	No	4
31	9	M	Bill	10ml	3/2	2/2	1/1	No	5
32	9	F	R	5ml	4/1	1/1	0/0	No	5
33	9	M	L	5ml	2/2	2/2	0/0	No	5
34	11	F	R	5ml	5/2	3/1	2/1	No	5
35	9	M	R	4ml	3/3	4/1	5/3	No	5
36	9	M	L	5ml	4/4	3/3	2/2	No	4
37	9	M	Bill	7ml	4/3	3/4	3/3	No	4
38	9	F	L	5ml	5/5	4/4	3/3	Yes	5
39	9	M	L	5ml	1/1	1/3	1/1	No	5
40	9	M	R	6ml	3/2	2/2	0/1	No	4

Abbreviation: Volume(G), Volume of graft; S, Pain score; B, Bed-rest; A, Ambulation; Stay, length of hospital stay

Table 2. Reviewed literature

Study	Wound length(cm)	Graft volume (ml)	Pain	Postoperative ambulation	Sensory disturbance	Hospital stay(D)
Kawamoto (1978)	5 (open)	None	None	None	None	None
Canady (1993)	4.2 (open)	4.1	45% moderate, 22% severe	93% in 24 hour	7%	2-3
Dawson (1996)	None (open)	None	Mild under PCA use	48 hours	None	80% discharge on 2nd day
Ruddman (1997)	2.9 (open)	4.1	None	3hr 18min	None	95.5% discharge on 2nd day
Bagain (2009)	4cm (open)	None	None	10.4 days	8%	3
Barone (2011)	4 (open)	None	5.5 (scale 0-10)	Difficulty in 24 hours	52.3%. All resolved eventually	None
Scott (1984)	2.5 (trephine)	None	None	None	None	None
Caddy (1985)	1-1.5 (trephine)	None	None	None	None	None

Table 2. Reviewed literature (continue)

Study	Wound length(cm)	Graft volume (ml)	Pain	Postoperative ambulation	Sensory disturbance	Hospital stay(D)
Thaller (1991)	1-1.5 (trephine)	None	None	None	None	None
Shepard (1987)	2 (osteotome)	None	None	None	None	None
Eufinger (2000)	2,4 (osteotome) 6 (open)	None	More analgesic in open group	None	None	None
Sandor (2003)	0.5-1(trephine) 6(open)	None	More painful in open group	0.8day(trephine) 2.8 day (open)	None	2.2(trephine) 4.1 (open)
Constantinides (2008)	None (open versus osteotome)	4.47 (open) (osteotome)	5 More analgesic in open group	Delay in open group	None	Longer in open group
Schaaf (2010)	2 (osteotome), >2 (open with saw)	None	More painful in open group	64% functional impairment	2%	None
Sharma (2011)	None (open versus trephine)	None	More painful in open group	None	None	1(trephine) 1.25 (open)
Wu (2013)	1 (minimal invasive open)	5.35	2.36 (scale 0-5)	2 hours	10%	4.55