ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 12, pp.63279-63284, December, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

DOES THE POSTERIOR ILIAC CREST HARVESTING TECHNIQUE HAVE LOWER RATE OF POSTOPERATIVE COMPLICATIONS THAN ANTERIOR ILIAC CREST HARVESTING TECHNIQUE? : A SYSTEMATIC REVIEW

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ARTICLE INFO

Article History:
Received 20th September, 2017
Received in revised form
23rd October, 2017
Accepted 05th November, 2017
Published online 31st December, 2017

Key words:
Anterior iliac crest, Posterior iliac crest, bone grafting, Postoperative morbidity, Gait disturbance, Reconstruction, A systematic review.

ABSTRACT

The aim of the current review was to answer this research question: Does the posterior iliac crest (PIC) harvesting technique has lower rate of postoperative complications than the anterior iliac crest (AIC) one. Online electronic databases were searched to detect articles published in English language from 2000 to 2016. Clinical human studies, comprising randomized controlled trials, controlled clinical trials, case series or retrospective studies whose purpose was comparing postoperative complications between AIC and PIC bone graft harvesting was selected.

Results: 16 articles were included in this systematic review from1358 relevant articles. A total of 1262 patients have undergone 1297 bone grafting procedure, with AIC (n=944) compared to PIC (n=353). Because of variations in the data presentation, meta-analysis could not be performed. PIC harvestinghas revealed to have lower postoperative complications (pain, gait disturbance, iliac crest fractures and sensory disturbance) than the AIC. However, no definitive conclusions can be drawn, asmost of the included studies were retrospective in nature. Thus, a prospective randomized clinical trial is requiredto substantially answer this significant research question.

Citation: Walaa K. Hafez, Essam A. Al-Moraissi and Maha M. Hakam, 2017. "Does the posterior iliac crest harvesting technique have lower rate of postoperative complications than anterior iliac crest harvesting technique?: A systematic review", *International Journal of Current Research*, 9, (12), 63279-63284.

INTRODUCTION

Autogenous bone graft harvested from the iliac crest is considered the gold standard against which all other grafts should be compared (Abramowicz *et al*., 2012). Being osteogenic, it provides large number of viable osteocompetent cells. It is rich in growth factors such as bone morphogenic proteins (BMPs) which induce new bone formation. Moreover, the cortico-cancellous grafts act as scaffolds through which creeping substitution by new bone occurs simultaneously with the resorption of native bone grafts (Riachi, 2014). AIC is the most commonly used site. Despite showing a high success rate, it carries along various donor site complications such as pain, parasthesia, hypersensitivity, contour defects, herniation of abdominal contents and pelvic instability (Becker *et al*., 2011). Moreover, fracture of the anterior superior iliac spine (ASIS) is a potential risk that results in a long standing gait disturbance (Kessler *et al*., 2005). Based on this, various studies claim that the AIC is associated with more donor site complications than the posterior site (Ahlmann *et al*., 2002), (Nkenke *et al*., 2004), (Kessler *et al*., 2005). Concerning the PIC, authors claim that it is associated with fewer complications than the AIC as it results in no gait disturbances and early patient mobilization (Marx and Morales, 1988). PIC provides abundant cortical and cortico- cancellous bone volume more than the AIC for maxillofacial reconstruction. However, it necessitates changing the patient position during surgery which increases the operative time and overall cost (Kessler *et al*., 2005). On the other hand, other studies claim that PIC is associated with comparable postoperative complications to the AIC because of the proximity to sciatic nerve and sacroiliac joint (Nkenke *et al*., 2004), (Becker *et al*., 2011). Despite various studies were concerned with the complications of both sites, there is no evidence that the AIC is associated with more donor site complications. Thus, the aim of the present study was to answer the following question: does the PIC harvesting technique have lower rate of postoperative complications than AIC harvesting technique?

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MATERIALS AND METHODS

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement for reporting systematic reviews (Moher *et al*., 2009). The current review included studies that aimed to assess the donor site complications of AIC and PIC and published from 2000 to 2016 on electronic

databases: Pubmed and Cochrane Central. Other sources were searched manually in the reference lists of the included studies and six journals more likely to contain studies relevant to the review topic: Journal of Oral and Maxillofacial Surgery; International Journal of Oral and Maxillofacial Surgery; British Journal of Oral and Maxillofacial Surgery; Journal of Cranio-Maxillo-Facial Surgery; American Journal of Orthodontic and Orthopedic and Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology; The searches were confined to the articles published in the English language. An attempt was made to identify the unpublished material or to contact authors of the published studies for further information. To complete the searches, the references of each selected publication that comparing AIC to PIC with regard to donor site complications were searched by hand. The study screening process was performed by the author.

Eligibility criteria

All clinical trials addressing iliac crest bone grafting and postoperative morbidity were included. The study designs that were adopted in accordance with the PICOS criteria and human studies were included, while other non-relevant designs were excluded. The electronic search and the PICO strategy are shown in (Table 1, 2).

Table 1. Electronic search on PubMed

Patients/ problem (P)	All patients with bony defect who are required /indicated for reconstruction, augmentation and rehabilitation using either AIC or PIC harvesting site.
Intervention (I)	Posterior iliac crest harvesting site (PICHS).
Comparator/ control gp (C)	Anterior iliac crest harvesting site (AICHS).
Outcome (O)	Postoperative complications as pain, gait disturbance, nerve injury, iliac crest fracture (primary outcome) and Surgical time, bone volume and patients and surgeons preference (secondary outcome).
Study design (S)	Clinical human studies, including randomized controlled trials, controlled clinical trials, case series or retrospective studies whose aim was comparing postoperative complications (morbidity) between AICHS and PICHS when used for reconstruction of bony defects .
Focused question	Does the PIC harvesting technique have lower rate of postoperative complications than AIC harvesting technique?

Table 2. PICOS criteria for the systematic review

Population/P	#1- defect need reconstruction OR defect OR discontinuity OR deficit OR deficiency. (Mesh Terms)
Intervention/I	#2- posterior iliac crest. (Mesh Terms)
control /C	#3-Anterior iliac crest. (Mesh Terms)
Outcome/O	#4- morbidity OR complications OR bone volume (Mesh Terms)
Search combination	(#1OR # 2 OR #3 OR #4) AND randomized controlled trial

Data collection process

From the selected databases, the titles of the retrieved articles were carefully assessed for eligibility by the authors; and the relevant abstracts that fulfill the inclusion criteria were assessed. Eligible articles were then reviewed independently in full text version by two examiners and any disagreements werediscussed with another author until consensus was reached**.** Then, the following data was extracted: authors, year of publication, study design, number of patients, gender (male: female ratio), mean age in years and number of patients suffered from donor site complications in terms of pain, gait disturbance, nerve injury and sensory disturbances. Also the surgical time and bone volume have been reported.

RESULTS

A total of 1358 titles from Pubmed and 27 from Cochrane were identified by the electronic database search (Fig. 1). After initial screening of titles and abstracts; non-eligible studies were excluded by reviewing titles and abstracts. Finally, the search identified 16 full articles that were included in this systematic review of assessment of postoperative complications of AIC versus PIC bone graft harvesting (Skaggs *et al*., 2000), (Robertson and Wray, 2001), (Ahlmann *et al*, 2002), (Sàndor *et al*., 2003), (Nkenke *et al*., 2004), (Joshi and Kostakis, 2004), (Kessler *et al*., 2005), (Shamsaldin *et al* , 2006), (Rawpashdeh, 2008), (Baqain *et al*., 2009), (Riyadh, 2009), (Barone *et al*., 2011), (Becker *et al*., 2011), (Matsa *et al*, 2012), (Dawson *et al*., 2014), (Riachi, 2014). Of these, 5 studies were controlled trials(Ahlmann *et al*, 2002), (Nkenke *et al*., 2004), (Kessler *et al*., 2005), (Becker *et al*., 2011), (Dawson *et al*., 2014) and the remaining studies were case series (Skaggs *et al*, 2000), (Robertson and Wray, 2001), (Sàndor *et al*., 2003), (Joshi and Kostakis, 2004), (Shamsaldin *et al*., 2006), (Rawashdeh, 2008), (Baqain *et al*., 2009), (Riyadh, 2009), (Barone *et al*., 2011), (Matsa *et al*., 2012).

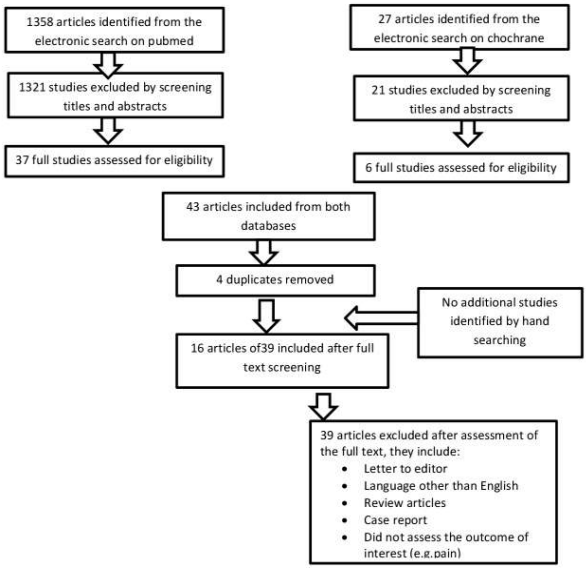

Figure 1. Flow diagram of the article selection process

Characteristics of included studies

The sixteen articles included in this study were published in a period from 2000 to 2014. A total of1262 patients have undergone 1297 bone grafting procedure with AICBG (n=944) (Riachi, 2014), (Becker *et al*., 2011), (Kessler *et al*., 2005), (Ahlmann *et al*., 2002), (Nkenke *et al*., 2004), (Dawson *et al*.,

2014), (Joshi and Kostakis, 2004), (Sàndor *et al*., 2003), (Matsa *et al*., 2012), (Riyadh, 2009), (Shamsaldin *et al*., 2006), (Rawashdeh, 2008), (Barone *et al*., 2011), (Baqain *et al*., 2009)compared to PICBG (n=353) (Ahlmann *et al*., 2002), (Skaggs *et al*., 2000), (Robertson and Wray, 2001). The age of the patients that underwent a bone harvest ranged from 9-54 years. In the sixteen included studies, there were 5 studies comparing AIC to PIC regarding pain, gait disturbance, operative time, sensory disturbances and bone volume (Becker *et al*., 2011), (Kessler *et al*., 2005), (Ahlmann *et al*., 2002), (Nkenke *et al*., 2004), (Dawson *et al*., 2014); 9 studies assessed AIC regarding pain, gait, sensory disturbance and fracture(Riachi, 2014), (Sàndor *et al*., 2003), (Matsa *et al*., 2012), (Riyadh, 2009), (Shamsaldin *et al*., 2006), (Rawashdeh, 2008), (Barone *et al*., 2011), (Baqain *et al*., 2009), (Skaggs *et al*, 2000) and 2 studies assessed PIC regarding pain, bone volume and sensory disturbance (Skaggs *et al*., 2000), (Robertson and Wray, 2001). [18, 19]

Results of individual studies

Pain & gait disturbance

Local pain following bone graft harvest is considered the main drawback of the procedure (AIC or PIC) (Behairy and Al-Sebai, 2001), (Heidecke *et al*., 2000), (Hill *et al*., 1999), (Silber *et al*., 2003). Pain is defined as temporary when it persists for less than six months and as residual when exceeds six months (Ahlmann *et al*., 2002).Various pain scores reported secondary to the bone grafting harvesting procedure are presented in details for both groups in Table 3. There is a strong correlation between pain and gait disturbance, meaning that patient who suffers more pain will have more gait problems (Joshi and Kostakis, 2004). Functional impairment postoperatively was found greater in the anterior group when compared to the posterior group (Becker *et al*., 2011), (Kessler *et al*., 2005), (Nkenke *et al*., 2004). The same is true for the need for crutches to assist their ambulance (Becker *et al*., 2011). Rawashdeh *et al* 2008 reported that the average duration of a limp/walking problem following AIC graft harvest was 6.6 +/- 5.4 days (range 0–25). At 1week, the number of patients suffered from gait disturbance following AIC graft harvest was 409 (41 %) but at 4 weeks, only 13 patients retained gait problems (1.37%). Moreover, 91.8 (9.7 %) required crutches or walking stick for gait assistance. While following PIC bone graft harvest, only 30 patients (4.9 %) reported gait difficulties and eight (2.2 %) of them needed crutches.

Sensory disturbances

They usually result from injury to the lateral femoral cutaneous nerve (LFCN), causing temporary or permanent sensory impairment of the lateral thigh (Kurz *et al*., 1989), (Mischkowski *et al*., 2006). Sensory disturbances which were reported in the included studies have involved numbness, hyposthesthesia, neuropraxia and temporary sensory loss over small or larger areas of the thigh. Repeated point blunt discrimination test was used(Barone *et al*., 2011) to assess presence or absence of hypoesthesia.

Iliac crest fracture

Iliac crest fracture which was described in literature (Guha and Poole, 1983), (Reynolds *et al*., 1978) might be attributed to harvesting the bone graft too close to the iliac spine.

Table 3. Pain scores for the included studies

Author	AIC	PIC
Nkenke, 2004	VAS day 2=7.0+/-1.5, VAS day 7 =3.7+/-1.4, VAS day 30=1.4+/-0.7	VAS day 2 =5.5+/-1.8, VAS day 7 =3.2+/-1.6, VAS day 30=1.4+/-0.8
Kessler 2005	57 pt. (70%)	15(33%)
Becker, 2011& Dawson, 2014	24 pts Average pain duration =14 days at 1 y :3 pts of 28 reported VAS more than 5	29 pts 21 days 1 pt. of 29
Joshi, 2004	80 pts suffered post-operative pain	----------
David Skaggs, 2000	----------	21 patients (1.4%) reported pain one each at 6, 7, and 9 months
George, 2003	1 pt. (1.2%) described having pain for more than 3 days	----------
Ahlmann, 2002	1 pt.: pain last more than 6 month 3 pt. mild pain lasting (2w- 4 m)	Less severe pain and for shorter period
Sainath Matsa, 2012	At 1w: 13 pts had score 2, 5 pts had score 3 At 1 m: 4 pts had score 2, 12 pts had score 1 and 2 pts had score 0. At 3 m: 2 pts had score 1 and 16 pts had score 0.	---------- ---------- ----------
Peter, 2001	----------	13 pts suffered pain Mean pain scores: 1.6 at 3 months, 1.8 at 6 months, and 1.2 at 12 months. Pain score of 0 was reported by 55% of the patients. Local sensory loss was found in 10% of the patients
Safaa Riyadh, 2009;	2 pts (5%) had transient donor site pain	----------
Shamsaldin, 2006	VAS on the 2nd day: >7 by 4 pts, 5–7 by 27 pts, and <5 by 19 pts. VAS at 1w: none of the pts indicated a VAS>7, 1 pt.'s VAS score was 6 and 49 pts reported a VAS<5. VAS after2 months: in 45 pts VAS= 0and the remaining 5 had a VAS<5 After 1 year follow-up: 46 pts had no pain (VAS=0) while a frequent discontinuous local impeding nuisance (VAS=1) was repeatedly described by3 pts.	--------
Fawzi Riachi, 2013	52 pts reported pain	----------
Rawashdeh, 2008	59 pts suffered pain and 3 pts reporting no pain. average duration of pain 10.5 +/- 8.3 days After 2 w: Two thirds of the pts (41 pts) reported no pain At 4w: 59 pts were pain free At 8 w: (7.8%) reporting no pain average VAS 3.8 +/-1.8	----------
Barone, 2011	99% (233)complained of pain 1 w postop, VAS mean value was 5.5 2w later, 63.8% (149.9) of pts reported pain. The mean VAS value was 3.3 At 3w:21.2% (49.8) of pts still complained of pain. The mean value of VAS was 3. At 1m:, only 1% (2.35) of pts report pain. At 6 weeks no pts reported pain	---------- ---------- ----------
Baqain, 2009	2 reported mild residual scar tenderness (8%) and 1 of the latter complained of tenderness on palpating the iliac crest (4%)	-----

(Pt.: patient, VAS: Visual analogue scale.)

Table 4. Complications rate, AIC versus PIC

	Pain	Gait Disturbance	Sensory disturbance	Fractures	Infection	seroma	Bleeding	Dehiscence	hematoma
AIC	620	409	197	7	14	1	7	5	20
(total=944)	(65.7%)	(41%)	(20.9%)	(0.74%)	(1.48%)	(0.11%)	(0.74%)	(0.52%)	(2.1%)
PIC	82	30	15	0	2	3	0	0	2
(total=353)	(25%)	(9%)	(4.6%)	(0%)	(0.61%)	(0.92%)	(0%)	(0%)	(0.61%)

Sensory disturbances

This could predispose to separation of the ASISfrom the iliac wing. Joshi and Kostakis have reported five cases of iliac crest fracture. Post-operative fall might have contributed to the fracture in three of them. However, all the cases were treated conservatively with bed rest and physiotherapy as there was no radiographic evidence of displacement. Barone *et al*, 2011 reported one case of fracture at ASIS in a 54-year-old woman that healed spontaneously after 4 months.

Other complications

They includedseroma, hematoma, scar dissatisfaction, abdominal herniation, increased blood loss, dehiscence and infection. Seroma and hematoma formation can be reduced by suturing the incision in layers (Mazock *et al*., 2003). Seroma occurred in 1 patient in the anterior group and 3 patients of the posterior group. Twenty patients developed hematoma (2 superficial, 1 extensive and the remainder are not reported) in the anterior group and only two patients in the posterior group. Most patients were satisfied with their scar postoperatively in the anterior group. One case of abdominal herniation, 5 wound dehiscence, 7 hemorrhage, 9 postoperative local swelling, 2 deep infections, 2 superficial infections and another 10 cases of infection; their type were not identified (Table 4). The PIC harvestresulted in less intraoperative blood loss (85 mL) compared to the AIC (177ml) with statistically significant difference (Abramowicz *et al*., 2012) while Ahlmann*et al* 2002 reported no significant difference in the blood loss (both 75 ml) between AIC and the PIC. However, the mean total blood loss was higher for the AIC (232.47 mL) than the PIC group (169.14 mL). Only 1 patient complained of a bone contour defect (Barone *et al*., 2011).

Bone volume

Greater bone volume was usually associated with the PICBG harvest (Becker *et al*., 2011), (Kessler *et al*., 2005), (Ahlmann *et al*., 2002), (Dawson *et al*., 2014) which is considered an advantageous approach when large bone volumes are needed, as in bilateral mandibular reconstruction.

DISCUSSION

Reviewing literature, the postoperative complications could be divided to major and minor. Major or severe complication describes those which prolong the hospital stay, require another surgery or cause prolonged disability. Pain that persists more than six months, permanent sensory loss due to nerve injury, gait disturbance, deep infection, herniation of abdominal contents, fracture at the iliac donor site or vascular injury are considered major complications (Ahlmann *et al*., 2002), (Riyadh, 2009), (Robertson and Wray, 2001). Minor complications are those that heal spontaneously without treatment, respond to ordinary treatment or do not cause permanent disability. They involve transient pain and sensory loss, superficial infection or minor wound dehiscence(Riyadh, 2009). Ahlmann *et al*, 2002 reported three cases of major complications in terms of persistent numbness (more than six months) over the distribution of LFCN. Robertson & Wray, 2001 reported two major complications, one in the form of deep infection resulted from inner iliac table penetration with an abscess presented at PIC. The other one is significant soft tissue defect resulted from gluteus maximus muscle detachment from its origin. Both complications required reoperation to manage infection and reattach the muscle respectively. Barone *et al*, 2011 reported two hematomas and one fracture as major complications. Fawzi *et al*, 2014 documented hematoma as a major complication and contributed it to the surgical technique and excessive retraction of tensor fascia lata muscle and ligaments. Residual pain lasting for more than six months was reported in one patient after an AICBG procedure and reported in no patient following PICBG harvest (Ahlmann *et al*., 2002). The main causes of donor site pain include signals from intact nociceptors close to a nerve injury ahlsite, bone micro or macro-fractures, infection and hematoma (Shamsaldin *et al*., 2006). On a VAS scale (1-10), three patients reported pain score more than 5 after 1 year in the anterior group and one patient in the posterior group (Dawson *et al*., 2014). The pain duration ranged from 3 days to 4 months in the included studies. The reflection and retraction of the tensor fascia lata muscle are considered to be the main reasons for the increased rate of complications associated with the anterior approach in the most of studies (Caddy and Reid, 1985) while reflection of the gluteus maximus muscle in the posterior approach is not associated with functional impairment as this muscle is not primary to ambulation (Marx and Morales, 1988). The choice of the surgical approach to the ilium in literature was mainly based on the quantity of bone required for augmentation. Obviously the posterior approach is the one of choice for this purpose as it supplies approximately double the bone quantity compared to the anterior approach (Hall *et al*., 1991).

The most notable disadvantage of a PICBG harvest is the prolonged operative time because of the necessity to reposition the patient during surgery. On the contrary to PIC graft harvest, utilization of two team approach is applicable while harvesting AIC bone graft; hence decreasing the overall time (Dawson *et al*., 2014). In one study, authors tried harvesting PICBG with the patient in the lateral position to avoid a major positioning change (Dawson *et al*., 2014). In all studies, surgical time was longer for PIC bone graft harvesting than for the AIC. Potential impairment of the superficial sensory function exists for both approaches which peaks at one week and significantly decreases with the potential for recovery after 1 month. In one study, residual numbness persisted 6 months in three patients for the anterior group and one patient for the posterior group (Ahlmann *et al*., 2002). It was postulated that the potential complications of bone graft harvestingfrom PIC is greater than AIC because of the proximity to the sacroiliac joint and sciatic nerve but actually damage to these areas seldom occur (Nkenke *et al*., 2004). The potential limitations of this study were that the majority of included studies were retrospective in nature. Thus, biases could be introduced because of certain factors that could influence the choice between two harvesting methods. These confounder's factors are: the amount of the required bone graft, preference of surgeons and patients and necessity of immediate walking.

Conclusion

AIC bone graft harvest is associated with greater postoperative complications when compared to the PICas regards to donor site pain and functional impairment. However, no definitive conclusions can be drawn, because of the retrospective study design. Thus, a prospective randomized trial is recommended before a final conclusion.

Acknowledgements

Funding: None

All authors have reviewed and agreed to the submission.

Conflict of interest: Not exist

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