

Fracture of Anterior Iliac Crest Following Bone Graft Harvest in an Anorexic Patient: Case Report and Review of the Literature

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In the treatment of jaw bone atrophies, autologous bone is still considered the gold standard because of its excellent osteoconductive, osteoinductive, and osteogenetic proprieties and lack of immunogenicity, which allow better graft integration and stability. Although various donor sites are available, the iliac crest represents the best source of corticocancellous bone, and literature suggests that it has low morbidity. However, this case report emphasizes that patients with systemic diseases such as anorexia should be carefully evaluated before such an operation, because unfavorable bone conditions may jeopardize the outcome. A 47-year-old woman needing rehabilitation of the upper arch was considered for iliac crest harvesting. She stated that she had suffered from anorexia for 30 years. A corticocancellous block was harvested by a bone saw using an anterolateral approach to the outer table of the right anterior iliac crest. The postoperative course was uneventful, but 13 days later, she complained of a sudden pain in the operated area, and X rays revealed a fracture of the anterior iliac crest. So far, the literature has mentioned 50 cases of iliac crest fractures after bone harvesting, and 28 cases among these are due to harvesting in the anterior part of the iliac crest. Several factors seem to be responsible for this complication, including the area of harvesting, residual bone thickness, technique used, and age and gender of the patient. To our knowledge, our case is the first of hip fracture after bone harvesting in a patient suffering from anorexia. Both low weight and osteoporosis are probably responsible for this complication. In our opinion, patients suffering from anorexia should be considered at risk for bone harvesting, and an appropriate mini-invasive surgical technique should be carried out instead.

Key Words: *iliac crest harvesting, anorexia, fracture*

INTRODUCTION

Although a large number of studies have underlined that allogenic, xenogenic, or synthetic materials have important clinical applications in the treatment of jaw bone loss, nowadays

autologous bone still represents the gold standard for its excellent osteogenetic characteristics.^{1,2} Indeed, autologous bone has great osteoconductive, osteoinductive, and osteogenic properties and lack of immunogenicity, which guarantee better integration, stability, and vital bone support for implantology.^{1,2} When choosing a donor source of nonvascularized bone, the surgeon should take into account the characteristics and size of the defect.³ If the amount of bone needed is limited, intraoral sites will be suitable, but if larger amounts

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DOI: 10.1563/AAID-JOI-D-10-00153

TABLE

All cases of fractures of the iliac crest described in the literature until today*

Author	Year	No. of Cases	Iliac Region	Specialty
Lichtblau et al ¹⁵	1962	1	Posterior	Orthopedic
Coventry et al ¹⁴	1972	6	Posterior	Orthopedic
Reynolds ¹⁶	1978	1	Anterior	Neurosurgery
Reale et al ¹⁷	1979	1	Anterior	Neurosurgery
Hall and Smith ¹⁸	1981	2	Not found	Oral maxillofacial
Blakemore ¹⁹	1983	1	Not found	Not found
Guha and Poole ³³	1983	1	Anterior	Plastic surgery
Ubhi and Morris ³⁴	1984	1	Not found	Not found
Kuhn and Moreland ²⁰	1986	2	Anterior	Orthopedic
Cohn and Krackow ²¹	1988	1	Anterior	Orthopedic
Consolo et al ²²	1990	1	Anterior	Oral maxillofacial
Hu et al ²³	1994	10	Anterior	Orthopedic
Friend et al ²⁴	1995	4	Posterior	
		1	Anterior	Not found
Porchet and Jaques ²⁵	1996	2	Anterior	Neurosurgery
Arrington et al ²⁶	1996	2	Anterior	Orthopedic
Fernando et al ²⁷	1999	1	Posterior	Not found
Neo et al ²⁸	2000	1	Anterior	Not found
Nocini et al ³	2003	1	Anterior	Oral maxillofacial
Zijderveld et al ²⁹	2004	3	Antero-medial	Oral maxillofacial
Al-Sayyad ³⁰	2006	3	Anterior	Orthopedic
Velchuru et al ³⁵	2006	1	Not found	Orthopedic
Oakley et al ³¹	2007	1	Posterior	Orthopedic
Arribas-Garcia et al ³²	2009	1	Anterior	Oral maxillofacial
<i>Current study</i>	2009	1	Anterior	Oral maxillofacial

*The cases have been divided considering both the area of fracture and the type of surgery.

of bone are required, extraoral site grafts will be necessary.⁴⁻⁶ Although different extraoral sites for the harvesting of nonvascularized bone are available, the iliac crest is the most common, both in orthopedic surgery and in craniomaxillofacial surgery.^{7,8} It is well known that the iliac crest is an important donor site for cancellous, cortical, and corticocancellous bone, since it provides the highest concentration of osteocomponent cells and available volume.

Different areas of the iliac crest are used to obtain dissimilar types of bone grafts in relationship to the surgery required. For instance, orthopedists and neurosurgeons prefer the posterior part of the iliac crest, while oral maxillofacial surgeons usually take bone from the anterior region.^{9,10} Analysis of literature shows different percentages of complications including vascular and neurological injuries, herniation of abdominal organs, accidental perforations, fractures of the iliac wing, infections, and chronic donor site pain.^{11,12}

The fracture of the anterior iliac crest following bone grafting is a rare but documented occurrence,

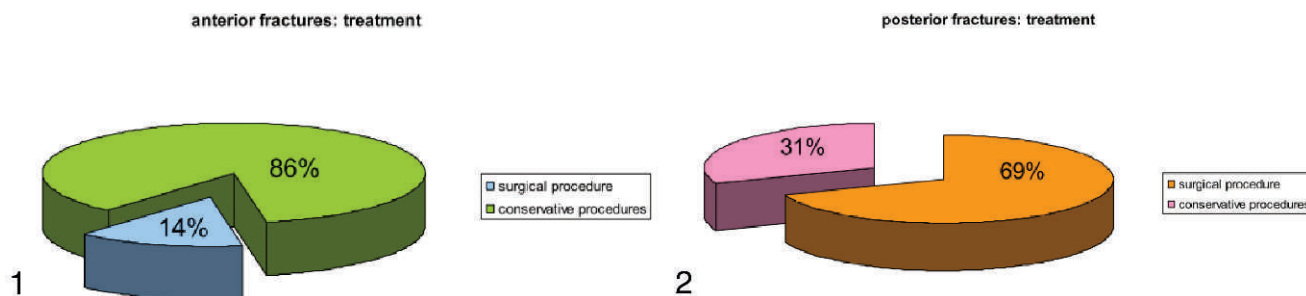
even though many reports were found in the orthopedic literature.^{7,13}

Some authors described severe dislocation of the left sacroiliac joint inducing instability of the pelvic ring and pubic fracture. All of these consequences occurred several months after the intervention.^{14,15}

However, the first case of fracture of the anterior superior iliac spine (ASIS) was observed by Reynolds et al¹⁶ 2 weeks after monocortical bone graft harvesting from the right anterior iliac crest. No particular treatment, apart from rest, was prescribed.¹⁶

Over the years, other authors have described similar complications,^{3,11,17-32} and in most of the cases, only a conservative treatment was successfully applied (Figures 1 and 2). Some authors reported hematomas and bowel herniations in the area of intervention³³⁻³⁵ as well as fractures. The Table summarizes all of the cases of iliac fracture described in the scientific literature.

It should be taken into account that many variables may influence the occurrence of this complication. First, the method by which bone is



FIGURES 1 AND 2. **FIGURE 1.** The literature indicates that a high percentage of anterior fractures received conservative treatments successfully (86%). **FIGURE 2.** In contrast, a large number of fractures of the posterior part need surgical intervention.

obtained from the donor site plays a role in determining donor site morbidity. In addition, race and factors such as age, gender, and medical conditions represent other important parameters to consider for the outcome of this surgical intervention.

In the light of these considerations, this article has the aim of reviewing recent literature about fractures after iliac crest harvesting using our case report as a starting point for discussion.

CASE REPORT

A 47-year-old woman consulted our department to rehabilitate her upper arch affected by tooth mobility and partial edentulism.

For several reasons, including her young age and appearance, she rejected the use of a complete removable denture. Therefore, the placement of dental implants both in the maxilla and in the posterior part of the mandible was taken into consideration as the first therapeutic choice.

During the checkup, several questions about medical and dental problems were made. From a medical point of view, she appeared to be in good health. She reported 2 previous surgical interventions consisting of safectomy and ovary ablation. Moreover, she declared that she had suffered from anorexia for 30 years and that she had been hospitalized 5 years previously in a psychiatric department for some weeks as a consequence of a worsening of the disease.

Parameters such as height and weight were evaluated before the intervention. She weighed 38.8 kg, and she was 1.62 m tall. As a consequence, her body mass index was 15. A moderate consumption of cigarettes (fewer than 10 cigarettes a

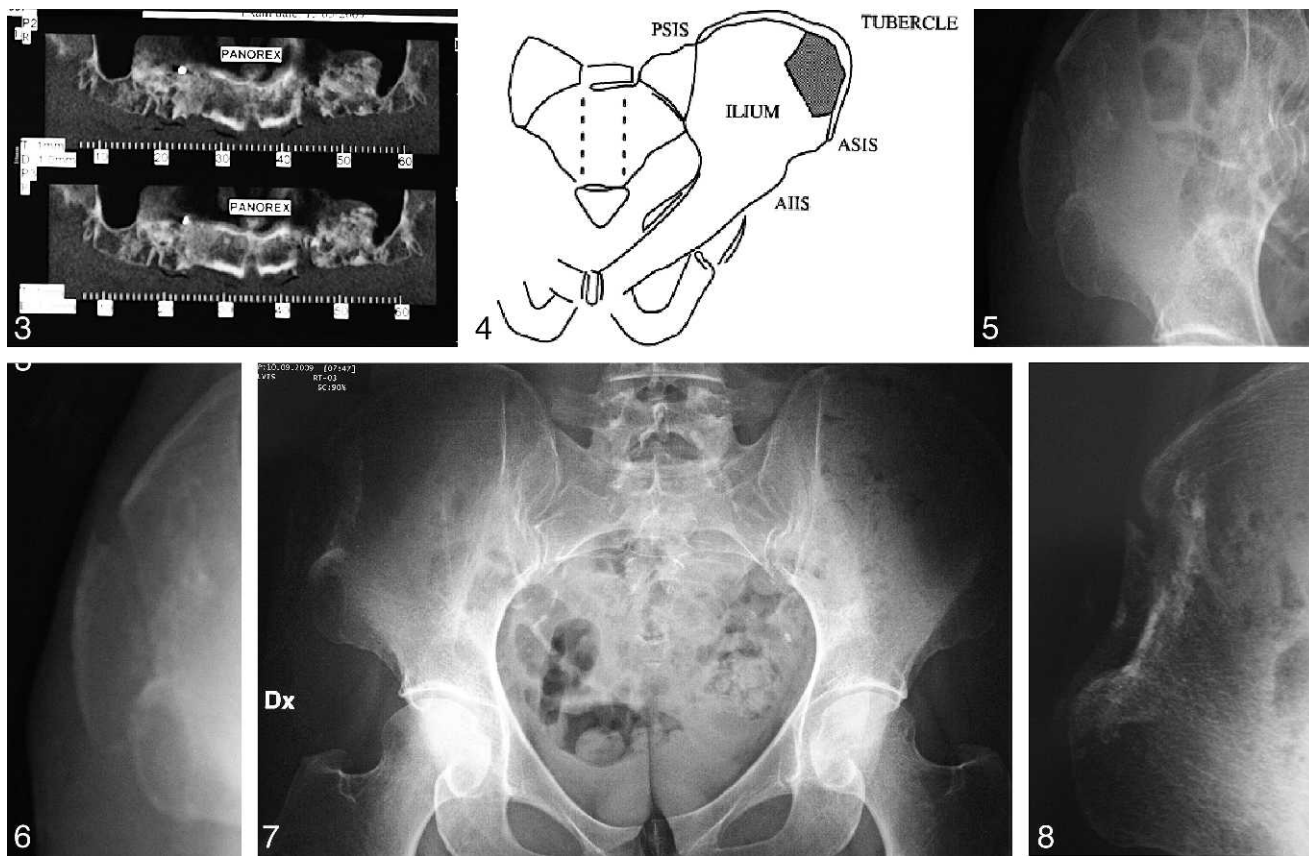
day) was not considered as a contraindication to implant placement, although the oral surgeon warned her to cut down.

From a dental point of view, the patient complained of tooth mobility and mild pain to the superior teeth.

The clinical examination showed a presence of 11,13, 14 suffering from advanced periodontitis with mobility of class II–III. Severe peri-implantitis involved 5 and 12, and they showed class II mobility.

In addition, severe bone atrophy and pneumatization of both maxillary sinuses were observed on X-ray examination (Cawood Howell class V). To be more precise, a TC-DENTALSCAN examination indicated an average of 5.22 mm residual bone thickness in the area under the left sinus and of 9.0 mm in the area under the right sinus (Figure 3). Therefore, a bilateral sinus lift and placement of onlay grafts on the anterior part of the maxilla were planned. Since the necessity of cortical bone for the onlays and corticocancellous bone for sinus augmentations was significant, the surgeon evaluated the iliac crest as the donor site.

The surgical procedure was carried out under general anesthesia. A corticocancellous block was harvested by a bone saw using an anterolateral approach to the anterosuperior margin of the right anterior iliac crest, as indicated in Figure 4. The anterior osteotomy was placed 2 cm from the ASIS, so as to avoid any weakening of the pelvic ring. All muscular attachments were preserved. After this, the graft was 6-cm long and 2-cm high, including superior cortical plate. Cancellous bone was taken using a spoon, and it was used to fill the sinuses. Donor site closure was obtained by suturing the periosteal layer, gluteal fascia, and subcutaneous



FIGURES 3–8. **FIGURE 3.** Panorex shows the residual amount of bone in the maxillary area before the intervention. **FIGURE 4.** Schematic drawing of the area of intervention. The monocortical bone graft is harvested from the anterior part of iliac crest, on the outer table. The anterior osteotomic line is 2-cm distal from the anterior superior iliac spine (ASIS). **FIGURES 5 AND 6.** X rays show the fracture of the anterior portion of the iliac crest. The oblique fracture lines start at the level of the tubercle involving ASIS. **FIGURES 7 AND 8.** X rays have been repeated after 2 months. These images showed an incomplete healing of the fractured area probably due to anorexic conditions.

tissue. Intradermal sutures were provided for skin closure to prevent scarring.

The postoperative course was uneventful, and the patient was discharged on the second day. At that time, she did not report any significant pain or symptoms such as hypoesthesia or dysesthesia. After a week, the removal of sutures and a control checkup were carried out, and no complications were observed.

Thirteen days after the intervention, the patient came to the emergency department of the hospital complaining of acute pain in the right iliac crest area. The patient reported that a sudden pain had started the previous evening when she was walking down the stairs.

Clinical examination revealed pain in the area, but no swelling or other signs were observed. Therefore, the surgeon prescribed X rays of the pelvis and the consultation of an orthopedic

surgeon to evaluate if a second intervention was necessary (Figures 5 and 6). The X rays indicated a fracture of the lateral surface of the right iliac crest including the ASIS. The fragment appeared slightly displaced, although the muscles were keeping it in place. According to the orthopedic surgeon, no surgical treatment was necessary, and only conservative therapy was prescribed. This consisted in resting with no weight applied to the leg.

X rays were carried out 2 months later (Figures 7 and 8). Although complete bone reformation had not been obtained at that point, X rays showed a gradual formation of callus, and the patient reported only mild pain in the area during particular movements such as walking down the stairs.

The next checkup confirmed complete healing of the patient.

DISCUSSION

Despite the fact that a large number of biomaterials are successfully used in regenerative procedures in oral maxillofacial surgery, autologous bone graft is still considered to be the gold standard.^{36–42}

Although the tibia, calvarium, and ribs are taken into account as donor sites, the iliac crest represents the site of choice for many authors. Points in favor of the hip are the relative simplicity of the surgical technique, the amount of available osseous material, the possibility of obtaining cancellous or cortical bone, low morbidity, and, finally, the excellent results achieved with these grafts.^{39,40,43,44} Common complications of bone harvesting from the iliac crest are intraoperative fractures of the outer table, excessive blood loss, postsurgical pain, and gait disturbances.^{7,45}

According to the literature, the fracture of the iliac crest after bone harvesting should not be considered a frequent complication. So far, the literature has indicated 50 cases of iliac crest fractures after bone-harvesting intervention, and 28 cases among these are due to harvesting from the anterior part of the iliac crest (Table).

The mechanism involved in the fracture of the anterior part of the iliac crest is related to the attachment of muscles in this area. Sartorius muscles and tensor fascia latae muscle attach themselves in this area, so their downward pull may represent a triggering factor. Moreover, the amount of bone harvested plays a crucial role in residual iliac crest strength. Hu et al⁴⁵ examined the differences in iliac crest strength after the removal of 15 mm or 30 mm of bone. They concluded that harvesting 30 mm of bone in the posterior rather than the anterior iliac spine allows us to preserve 2.4 times more strength than removing 15 mm of bone in the anterior iliac spine.⁴⁵

As a matter of principle, most authors suggest that the distance between the graft area and the anterosuperior spine should not be less than 2 to 3 cm, so that support to the muscles is not weakened. Moreover, the area between the ASIS and the anteroinferior iliac spine represents an area of low resistance where a fracture can occur if the bone is harvested close to the ASIS. Therefore, the weakening of the iliac bone could induce the detachment of ASIS or contribute to the fracturing of the lateral wall as well.

In addition, the thickness of grafting is correlated

to the weakening of residual iliac crest. Indeed, a monocortical graft can be considered as lower risk than a bicortical or tricortical one. As far as surgical technique is concerned, many authors have compared the use of saws versus osteotomes. Some studies evaluated the approach with 2 different instruments in 66 corpses and concluded that the use of osteotomes induce a higher risk of fracture than the use of saws.⁴⁶

It is evident that the surgical technique has a crucial role in determining the outcome of the intervention. However, other parameters such as age, gender, race, and medical condition have often been underevaluated.

Age and gender should be carefully considered. Studies show that women older than 50 years are at higher risk, probably because of their osteopenic conditions. In addition to that, ligamentous laxity has been indicated as an unfavorable prognostic element in women considered for bone harvesting from the posterior part of the iliac crest. Finally, medical conditions should be evaluated with care so that the intervention may be carried out using an alternative technique if necessary.

According to our experience, patients suffering from systemic diseases such as anorexia should be carefully examined because, in the case of such diseases, the surgical technique employed should be modified. Anorexia nervosa (AN) is an eating disorder that usually begins in adolescence and is characterized by patient-induced and maintained weight loss that leads to progressive malnutrition and specific pathophysiological signs (disturbance of body image and fear of obesity).⁴⁷ As a result of AN, profound malnutrition and amenorrhea afflict most subjects.^{48,49} These 2 conditions induce serious damages to bone tissue, provoking osteoporosis and osteopenia.^{50,51} Several studies indicated that osteoporosis represents a common complication, involving 50% to 90% of cases depending on the group observed.^{52,53} As a consequence, subjects with AN have a higher risk of fragility fractures than the general population does.⁵⁴

Although the exact cause of osteoporosis in anorexic patients is still unclear, some researchers have put forward the hypothesis that estrogen deficiency and loss of body weight have an important role.^{51,53}

Although menstrual function and weight are considered to be at the same level of importance in

terms of causes of osteoporosis, several authors underlined that weight gain seems to be related to hip bone mass recovery, while menstrual function should be considered a critical factor in lumbar bone mass.⁵²

To our knowledge, this represents the first case described in literature of hip fracture after bone harvesting in a patient suffering from AN.

The bone graft was harvested from the outer table of the iliac crest using saws, and no fracture during surgery was revealed. After 2 weeks, the patient described a sudden crack with pain due to a fracture associated with an intensive contraction of the muscles. It is reasonable to think that AN may have encouraged the fracture, both inducing osteoporosis and reducing hip bone mass, as described in the literature. According to the literature, a conservative treatment was applied with rest and restriction in movements. Although a complete functional recovery after 40 days was achieved, X rays repeated after 2 months revealed an incomplete healing of the area, showing only a partial fusion. This fact is probably explained by unfavorable bone condition due to low weight.

The most important conclusion that can be drawn from our case report is that even though various factors such as surgical technique, amount of the bone graft, and age and gender play a role in possible complications, preexisting medical conditions are often underestimated.

In fact, AN should be considered as a relative contraindication for bone harvesting in oral and maxillofacial surgery. This is because this disease may encourage fractures as a complication. Thus, this case report suggests that surgeons should develop alternative techniques in order to limit the risk of fracture in such patients.

ABBREVIATIONS

AN: anorexia nervosa

ASIS: anterior superior iliac spine

REFERENCES

- Schliephake H, Schmelzeisen R, Husstedt H, Schmidt-Wondera LU. Comparison of the late results of mandibular reconstruction using nonvascularized or vascularized grafts and dental implants. *J Oral Maxillofac Surg.* 1999;57:944–950.
- Stevenson S. Biology of bone grafts. *Orthop Clin North Am.* 1999;30:543–452.
- Nocini PF, Bedogni A, Valsecchi S, et al. Fractures of the iliac crest following anterior and posterior bone graft harvesting: review of the literature and case presentation. *Minerva Stomatol.* 2003;52:441–448, 448–452.
- Wyatt JR, Stewart MJ, McCord PT. The femoral condyle as an alternative source of cancellous bone for grafting of maxillofacial defects. *J Oral Maxillofac Surg.* 1988;46:433–434.
- Catone GA, Reimer BL, McNeir D, Ray R. Tibial autogenous cancellous bone as an alternative donor site in maxillofacial surgery: a preliminary report. *J Oral Maxillofac Surg.* 1992;50:1258–1263.
- Frodel JL Jr, Funk GF, Capper DT, et al. Osseointegrated implants: a comparative study of bone thickness in four vascularized bone flaps. *Plast Reconstr Surg.* 1993;92:449–455.
- Kalk WW, Raghoebar GM, Jansma J, Boering G. Morbidity from iliac crest bone harvesting. *J Oral Maxillofac Surg.* 1996;54:1424–1429.
- Seiler JG III, Johnson J. Iliac crest autogenous bone grafting: donor site complications. *J South Orthop Assoc.* 2000;9:91–97.
- De la Torre JI, Tenenhaus M, Gallagher PM, Sachs SA. Harvesting iliac bone graft: decreasing the morbidity. *Cleft Palate Craniofac J.* 1999;36:388–390.
- Hutchinson MR, Dall BE. Midline fascial splitting approach to the iliac crest for bone graft: a new approach. *Spine (Phila Pa 1976).* 1994;19:62–66.
- Brazaitis MP, Mirvis SE, Greenberg J, Ord RA. Severe retroperitoneal hemorrhage complicating anterior iliac bone graft acquisition. *J Oral Maxillofac Surg.* 1994;52:314–316.
- Shin AY, Moran ME, Wenger DR. Superior gluteal artery injury secondary to posterior iliac crest bone graft harvesting: a surgical technique to control hemorrhage. *Spine (Phila Pa 1976).* 1996;21:1371–1374.
- Russell JL, Block JE. Surgical harvesting of bone graft from the ilium: point of view. *Med Hypotheses.* 2000;55:474–479.
- Coventry MD, Tapper EM. Pelvis instability: a consequence of removing iliac bone for grafting. *J Bone Joint Surg Am.* 1972;54:83–101.
- Lichtblau S. Dislocation of the sacroiliac joint: a complication of bone grafting. *J Bone Joint Surg Am.* 1962;44:193–198.
- Reynolds AF Jr, Turner PT, Loeser JD. Fracture of the anterior superior iliac spine following anterior cervical fusion using iliac crest: case report. *J Neurosurg.* 1978;48:809–810.
- Reale F, Gambacorta D, Mencattini G. Iliac crest fracture after removal of two bone plugs for anterior cervical fusion: case report. *J Neurosurg.* 1979;51:560–561.
- Hall MB, Smith R. The medical approach for obtaining iliac crest bone. *J Oral Surg.* 1981;39:462–465.
- Blakemore ME. Fractures at cancellous bone graft donor sites. *Injury.* 1983;14:519–522.
- Kuhn DA, Moreland MS. Complications following iliac crest bone grafting. *Clin Orthop Relat Res.* 1986;209:224–226.
- Cohn BT, Krackow KA. Fracture of the iliac crest following bone grafting: a case report. *Orthopedics.* 1988;11:473–474.
- Consolo U, Politi M, Nocini PF, Salgarelli A. Samples of iliac crest bone: a case report review and clinico-statistical evaluation [in Italian]. *Minerva Stomatol.* 1990;39:133–137.
- Hu RW, Bohlman HH. Fracture at the iliac bone graft harvest site after fusion of the spine. *Clin Orthop Relat Res.* 1994;309:208–213.
- Friend KD, Koval KJ, Mirovsky Y, Remer SS, Bloom N, Neuwirth MG. Fracture of the iliac crest following bone grafting: a case report and literature review. *Bull Hosp Jt Dis.* 1995;54:49–51.
- Porchet F, Jaques B. Unusual complications at iliac crest bone graft donor site: experience with two cases. *Neurosurgery.* 1996;39:856–859.

26. Arrington ED, Smith WJ, Chambers HG, Bucknell AL, Davino NA. Complications of iliac crest bone graft harvesting. *Clin Orthop Relat Res*. 1996;329:300–309.
27. Fernando TL, Kim SS, Mohler DG. Complete pelvic ring failure after posterior iliac bone graft harvesting. *Spine (Phila Pa 1976)*. 1999;24:2101–2104.
28. Neo M, Matsushita M, Morita T, Nakamura T. Pseudoaneurysm of the deep circumflex iliac artery: a rare complication at an anterior iliac bone graft donor site. *Spine (Phila Pa 1976)*. 2000;25:1848–1851.
29. Zijdeveld SA, ten Bruggenkate CM, van Den Bergh JP, Schulten EA. Fractures of the iliac crest after split-thickness bone grafting for preprosthetic surgery: report of 3 cases and review of the literature. *J Oral Maxillofac Surg*. 2004;62:781–786.
30. Al-Sayyad MJ, Abdulmajeed TM. Fracture of the anterior iliac crest following autogenous bone grafting. *Saudi Med J*. 2006;27:254–258.
31. Oakley MJ, Smith WR, Morgan SJ, Ziran NM, Ziran BH. Repetitive posterior iliac crest autograft harvest resulting in an unstable pelvic fracture and infected non-union: case report and review of the literature. *Patient Saf Surg*. 2007;1:6.
32. Arribas-Garcia I, Alcalá-Galiano A, García AF, Moreno JJ. Fracture of the anterior iliac crest following monocortical bone graft harvest in bisphosphonate-related mandibular pathological fracture: a case report. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2009;107:e12–e14.
33. Guha SC, Poole MD. Stress fracture of the iliac bone with subsfascial femoral neuropathy: unusual complications at a bone graft donor site: case report. *Br J Plast Surg*. 1983;36:305–306.
34. Ubhi CS, Morris DL. Fracture and herniation of bowel at bone graft donor site in the iliac crest. *Injury*. 1984;16:202–203.
35. Velchuru VR, Satish SG, Petri GJ, Sturzaker HG. Hernia through an iliac crest bone graft site: report of a case and review of the literature. *Bull Hosp Jt Dis*. 2006;63:166–168.
36. Allegrini S Jr, Yoshimoto M, Salles MB, Konig B Jr. The effects of bovine BMP associated to HA in maxillary sinus lifting in rabbits. *Ann Anat*. 2003;185:343–349.
37. Haas R, Donath K, Fodinger M, Watzek G. Bovine hydroxyapatite for maxillary sinus grafting: comparative histomorphometric findings in sheep. *Clin Implant Res*. 1998;9:107–116.
38. Jensen J, Simonsen EK, Sindet-Pedersen S. Reconstruction of the severely resorbed maxilla with bone grafting and osseointegrated implants: a preliminary report. *Int J Oral Maxillofac Surg*. 1990;48:27–32.
39. Jakse N, Seibert FJ, Lorenzoni M, Eskici A, Pertl C. A modified technique of harvesting tibial cancellous bone and its use for sinus grafting. *Clin Oral Implants Res*. 2001;12:488–494.
40. Karabuda C, Ozdemir O, Tosun T, Anil A, Olgac V. Histological and clinical evaluation of 3 different grafting materials for sinus lifting procedure based on 8 cases. *J Periodontol*. 2001;72:1436–1442.
41. Lundgren S, Rasmusson L, Sjoström M, Sennerby L. Simultaneous or delayed placement of titanium implants in free autogenous iliac bone grafts: histological analysis of the bone graft titanium interface in 10 consecutive patients. *Int J Oral Maxillofac Surg*. 1999;28:31–37.
42. Yildirim M, Spiekermann H, Biesterfeld S, Edelhoff D. Maxillary sinus augmentation using xenogenic bone substitute material BioOss in combination with venous blood. *Clin Oral Implants Res*. 2000;11:217–219.
43. Chanavaz M. Maxillary sinus: anatomy, physiology, surgery, and bone grafting related to implantology—eleven years of surgical experience (1979–1990). *J Oral Implantol*. 1990;16:199–209.
44. Khoury F. Augmentation of the sinus floor with mandibular bone block and simultaneous implantation: a 6-year clinical investigation. *Int J Oral Maxillofac Implants*. 1999;14:557–564.
45. Hu R, Hearn T, Yang J. Bone graft harvest site as a determinant of iliac crest strength. *Clin Orthop Relat Res*. 1995;310:252–256.
46. Jones AA, Dougherty PJ, Sharkey NA, Benson DR. Iliac crest bone graft: osteotome versus saw. *Spine (Phila Pa 1976)*. 1993;18:2048–2052.
47. Yager J, Andersen AE. Clinical practice: anorexia nervosa. *N Engl J Med*. 2005;353:1481–1488.
48. Herzog DB, Keller MB, Lavori PW. Outcome in anorexia nervosa and bulimia nervosa: a review of the literature. *J Nerv Ment Dis*. 1988;176:131–143.
49. Strober M, Freeman R, Morrell W. The long-term course of severe anorexia nervosa in adolescents: survival analysis of recovery, relapse, and outcome predictors over 10–15 years in a prospective study. *Int J Eat Disord*. 1997;22:339–360.
50. Maugars YM, Berthelot JM, Forestier R, et al. Follow-up of bone mineral density in 27 cases of anorexia nervosa. *Eur J Endocrinol*. 1996;135:591–597.
51. Muñoz MT, Argente J. Anorexia nervosa in female adolescents: endocrine and bone mineral density disturbances. *Eur J Endocrinol*. 2002;147:275–286.
52. Herzog DB, Hopkins JD, Burns CD. A follow-up study of 33 subdiagnostic eating disordered women. *Int J Eat Disord*. 1993;14:261–267.
53. Misra M, Klibanski A. Anorexia nervosa and osteoporosis. *Rev Endocr Metab Disord*. 2006;7:91–99.
54. Rigotti NA, Neer RM, Skates SJ, Herzog DB, Nussbaum SR. The clinical course of osteoporosis in anorexia nervosa: a longitudinal study of cortical bone mass. *JAMA*. 1991;265:1133–1138.