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Comparing Morbidities of Bone Graft Harvesting from the Olecranon Process and the Distal Radius

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Background: The aim of this study is to compare donor-site morbidities between patients who underwent bone graft harvesting from either the olecranon process (OP) or the distal radius (DR).
Methods: We evaluated 44 patients who underwent bone graft harvesting from the OP (25 cases) or the DR (19 cases) for various procedures in the ipsilateral upper extremity. Follow-up averaged 14 (OP group) and 19 months (DR group). Outcome measures included visual analog scales (VAS) for graft harvest-site pain and scar appearance, joint motion, and x-rays of the graft harvest and recipient sites. The VAS scores ranged from 0 to 10 with a low score reflecting no pain and excellent satisfaction and a high score reflecting severe pain and poor satisfaction.
Results: The VAS scores for pain averaged 0.4 (OP) and 0.5 (DR), and the VAS scores for scar appearance averaged 0.3 (OP) and 0.7 (DR). These differences were not significant. Within each group, there were no significant differences between the operative and nonoperative limbs for elbow or wrist motion. Early graft harvest-site complications involved 1 superficial wound infection (OP) and 1 wound dehiscence (DR). A graft harvest-site defect was detected by x-ray in 84% of OP cases and in 67% of DR cases. Bone healing at the graft recipient sites was observed in more than 87% of cases in both groups.
Conclusions: Bone graft harvesting from either the OP or the DR led to comparable patient- and evaluator-determined outcomes with low risks of complications. Surgeons can safely use either option. *(Plast Reconstr Surg Glob Open 2016;4:e623; doi: 10.1097/GOX.0000000000000617; Published online 19 February 2016.)*

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Autogenous bone is arguably the best source for bone grafting in the upper extremity given the inherent osteogenic, osteoconductive, and osteoinductive properties of living bone.[1] The transferred tissue does not incite an immune reaction, and the grafting procedure carries no intrinsic risk of transmissible disease. The iliac crest can be an abundant source of bone for most procedures in the elbow, forearm, wrist, and hand. However, there are potential complications with obtaining graft

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from this site, including chronic pain, infection, hematoma, incisional hernia, fracture, and disturbed sensation.[1–6] Recalcitrant donor-site pain has been reported to occur in up to 25% of patients after iliac crest bone harvesting.[3,6]

The olecranon process (OP) and the distal radius (DR) are convenient sources of bone graft harvesting for operations in the ipsilateral upper extremity. A comparable amount of packed cancellous bone can be obtained from either region.[7,8] Donor-site complication rates ranging from 1% to 8% have been reported in a large series of DR grafts for upper extremity procedures.[9–11] Reports of OP bone graft harvesting have comprised smaller numbers of patients, but with similar donor-site complication rates ranging from 0% to 9%.[9,12–16]

There are conceivable scenarios where one graft source may be preferred over the other graft source. For example, autogenous bone graft required for the treatment of a displaced scaphoid fracture would be preferred from a source other than the adjacent DR (eg, OP) when there has been a concomitant fracture of the DR. To our knowledge, there are no comparative studies evaluating donor-site morbidities among patients undergoing bone graft harvesting from the OP or DR. Furthermore, the harvesting techniques and the methodologies for assessing outcomes have been discordant in the published reports. The purpose of this study is to compare donor-site morbidities between patients who underwent graft harvesting from either the OP or the DR using uniform surgical techniques and outcome measures.

METHODS

Investigational review board approvals were obtained at the 2 institutions where this study was performed, and a written informed consent was obtained from all study participants. Patients aged 18 years or older who had either OP or DR bone graft harvested for an operation in the ipsilateral upper extremity between 2004 and 2014 were identified from the operative records of 4 fellowship-trained hand surgeons. The choice of bone graft source was at the discretion of the treating surgeon and/or the patient.

In an effort to focus attention on the bone graft harvest sites, only those patients whose donor site was positioned at least 1 joint or 1 bone away from the recipient site, or whose donor site was positioned in one end of a forearm bone with the recipient site at the far end of the same bone, were considered for the study participation. For example, patients undergoing a scaphoid fracture repair or a midcarpal arthrodesis were selected for the study if the bone graft had been obtained from the OP rather than the adjacent DR. A patient undergoing radial head fracture repair with bone graft harvesting was considered for study participation if the bone was obtained from the DR rather than the bordering OP.

Seventy-three patients who met our study inclusion criteria were identified. Forty-four patients agreed to participate at varying times throughout the 10-year study period and returned for follow-up evaluation at a minimum of 4 months after surgery. The OP group consisted of 25 patients (25 cases), 12 men and 13 women, with an average age of 47 years (range, 23–76 years). The DR group consisted of 19 patients (19 cases), 8 men and 11 women, with an average age of 42 years (range, 19–67 years). The dominant extremity was involved in 12 cases in each cohort. The procedures utilizing the bone grafts are listed in Table 1. The patients returned for follow-up evaluation at an average of 14 months (range, 4–51 months) after surgery in the OP group and 19 months (range, 6–66 months) after surgery in the DR group.

Bone Graft Harvesting Techniques

Olecranon bone graft was obtained through a 2- to 3-cm longitudinal incision along the subcutaneous border of the OP, beginning approximately 1 fingerbreadth distal to the olecranon tip (Fig. 1). The olecranon bursa was incised, and opposing periosteal flaps were raised using a freer elevator. A 6- to 10-mm oval window was created in the dorsal

Table 1. Procedures Using Bone Graft from the Ipsilateral Olecranon Process or Distal Radius

	Bone Graft	
Surgical Procedures	**Olecranon Process (n = 25)**	**Distal Radius (n = 19)**
Repair fracture distal humerus	0	1
Repair fracture olecranon	0	2
Repair fracture nonunion olecranon	0	2
Repair fracture radial head	0	1
Repair fracture distal radius (small fragment or external fixation)	10	0
Osteotomy distal radius	5	0
Repair fracture scaphoid	2	0
Repair fracture nonunion scaphoid	2	0
Arthrodesis mid carpal interval	3	0
Repair fracture–dislocation CMC joint	0	1
Repair fracture phalanx	0	3
Repair fracture nonunion phalanx	0	1
Revision arthrodesis MCP joint	0	1
Excision aneurysmal bone cyst metacarpal with allograft reconstruction	0	1
Curettage lesion metacarpal	0	1
Curettage lesion phalanx	3	5

CMC, carpometacarpal; MCP, metacarpophalangeal.

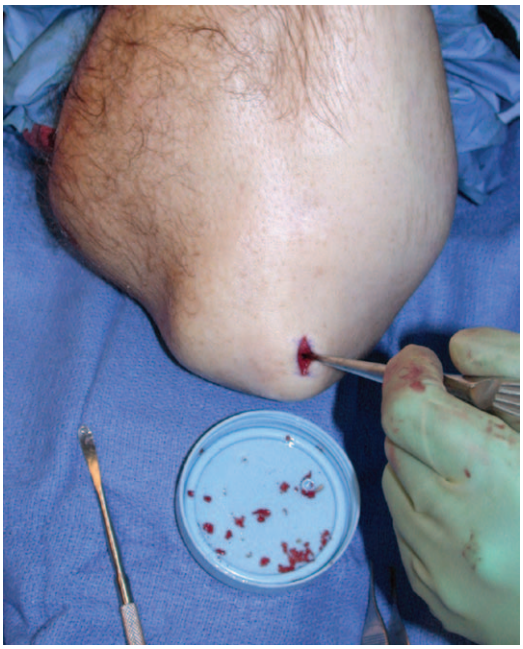

Fig. 1. Intraoperative photograph demonstrating the olecranon bone graft harvesting technique. A small oval-shaped window is created in the dorsal cortex of the olecranon process approximately 1 fingerbreadth distal to the tip. The removed cortical bone is mixed with the cancellous bone retrieved from the bony process. The periosteum and skin are closed in layers.

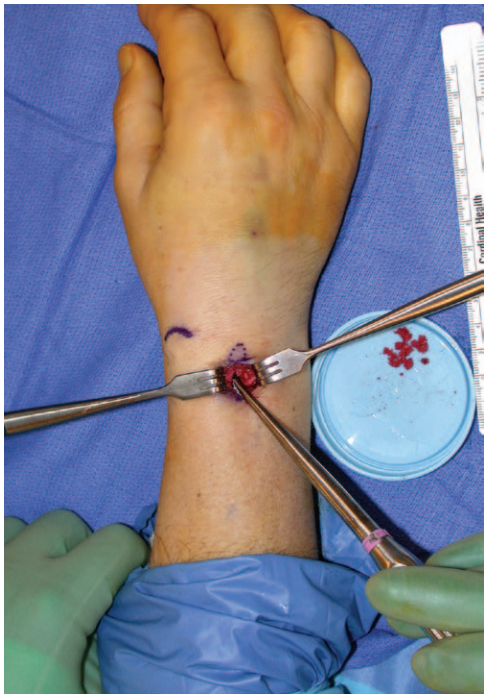

Fig. 2. Intraoperative photograph demonstrating the distal radius bone graft harvesting technique. A small oval-shaped window is created in the dorsal cortex of the distal radius, immediately proximal to the tubercle of Lister. The removed cortical bone is mixed with the cancellous bone retrieved from the distal radial metaphysis. The skin is repaired.

cortex using a small osteotome and curettes, and cancellous bone graft was obtained with straight and curved curettes. After obtaining a sufficient amount of cancellous graft for the planned procedure, the periosteal flaps and bursa were reapproximated with absorbable sutures. The skin was closed with either absorbable or nonabsorbable sutures, and a soft compressive dressing was applied. Postoperatively, all patients were permitted to move the elbow freely.

Distal radius bone graft was obtained through a 2- to 3-cm longitudinal incision extending proximal to the tubercle of Lister (Fig. 2). The interval between the extensor pollicis longus and the extensor carpi radialis brevis tendons was developed, and a 6- to 10-mm oval window was made in the dorsal cortex using a small osteotome and curettes. After obtaining adequate cancellous graft, the skin was repaired in the usual manner and a soft compressive dressing was applied. There was typically insufficient periosteum to close over the bone defect.

The fragments of cortical bone removed from the OP and DR were added to the cancellous autograft, and the mixture was packed into the recipient bone bed. Supplemental cancellous allograft was added to the autograft mixture in 1 patient from the OP group and in 1 patient from the DR group. At the discretion of the treating surgeons, gelfoam was placed into the graft harvest void in 20 of 25 OP cases and 12 of 19 DR cases, and cancellous allograft was packed into the graft harvest void in 1 case from each cohort.

Patient Survey

All study participants completed a nonvalidated visual analog scale (VAS) questionnaire at the latest follow-up evaluation. The questionnaire was designed to direct attention to the OP or DR bone graft harvest site and included queries of pain, swelling, and joint stiffness at the harvest site; the appearance of the harvest site; the ability to perform work activities in relationship to the harvest site; and overall satisfaction with having bone graft obtained from the site in question. The VAS scores ranged from 0 to 10 with a low score reflecting no pain and excellent satisfaction and a high score reflecting severe pain and poor satisfaction. To our knowledge, there are no validated outcome tools that would have permitted meaningful comparisons between patient groups because of the proximity of the bone graft harvest and recipient sites.

Physical Examination

A physician, a physician assistant, or a hand therapist obtained active joint motion measurements of

the operative and nonoperative elbows (OP group) and wrists (DR group) using a goniometer at the latest follow-up evaluation. In addition, the graft harvest sites were evaluated for point tenderness and a palpable defect. The examiners were not blinded to the surgical procedures that were performed.

Radiographic Analysis

The graft harvest site was assessed for a residual bone defect, and the graft recipient site was assessed for bone healing subjectively on the latest x-rays by 2 physicians who were not blinded to the surgical procedures that were performed.

Statistical Methods

Inclusion of at least 17 patients in each group was necessary to detect a difference of 1.0 in the VAS measurements between groups with a statistical power level of 0.8 and a probability level of 0.05. Descriptive statistics included percentages, means, and SDs. The χ^2 and Fisher's exact tests were used to compare categorical variables, and the 2-sample and paired Student's *t* tests were used to compare continuous variables. A level of significance was determined for a *P* value of less than 0.05.

Conflicts of Interest

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this article.

RESULTS

Patient Demographics

There were no significant differences between the OP and the DR graft harvest groups for patient sex ($P = 0.70$), patient age ($P = 0.32$), hand dominance ($P = 0.29$), operative extremity ($P = 0.32$), or follow-up interval ($P = 0.37$). However, there were significant differences between groups in regards to the bone graft recipient sites listed in Table 1 ($P < 0.001$).

Patient Survey

The average values for all VAS categories (pain, swelling, and joint stiffness at the harvest site; the appearance of the harvest site; the ability to perform work activities in relationship to the harvest site; and overall satisfaction with having bone graft obtained from the site in question) were less than 1. There were no significant differences between graft harvest-site groups (Table 2). Five patients in the OP group and 3 patients in the DR group described mild scar discomfort, and 2 patients in the OP group and 1 patient in the DR cohort reported mild swelling at the bone harvest site. There was only 1 patient in the study population who reported difficulty returning to work. This individual (OP group) worked as a personal trainer and noticed discomfort at the posterior aspect of his elbow when leaning on the graft harvest-site scar.

Physical Examination

In comparing the operative and nonoperative extremities within each group, there were no significant differences in the elbow motion (OP group) or wrist motion (DR group) measurements (Tables 3 and 4). A palpable defect at the graft harvest site was detected in 19 of 25 OP cases and in 3 of 19 DR cases; this difference was significant ($P < 0.001$). There was mild harvest-site tenderness in 3 OP patients and in 2 DR patients.

Radiograph Analysis

There was a visible radiographic defect at the graft harvest site in 21 of 25 OP cases and in 12 of 18 DR cases (radiographs of the wrist in 1 patient from the DR group could not be located). The difference between groups was not significant ($P = 0.28$). The bone graft recipient sites healed in 22 of 25 patients in the OP group and in 18 of 19 patients in the DR group. Two patients in the OP group who did not exhibit bone healing had had grafting performed for a scaphoid nonunion. The other patient in this group had had bone grafting performed for a midcarpal arthrodesis. One patient in the DR

Table 2. Visual Analog Scale Comparisons Between Patients Who Underwent Bone Graft Harvesting from the Olecranon Process or Distal Radius

Visual Analog Scale Queries	Bone Graft from Olecranon Process (n = 25)	Bone Graft from Distal Radius (n = 19)	*P*
Pain at the graft harvest site	0.4 (1)	0.5 (1.3)	0.72
Swelling at the graft harvest site	0.1 (0.4)	0.05 (0.2)	0.52
Joint stiffness at the graft harvest site	0.2 (0.6)	0.5 (1.4)	0.31
Satisfaction with the appearance of the graft harvest site	0.3 (0.6)	0.67 (1.2)	0.23
Work capabilities in relationship to the graft harvest site	0.5 (1.6)	0.8 (2.0)	0.57
Overall satisfaction with the graft harvest site	0.3 (1.1)	0.2 (0.5)	0.62

Measurements are recorded as mean (SD).

Table 3. Comparisons of Joint Motion Between the Operative and Nonoperative Extremities After Bone Graft Harvesting from the Olecranon Process

Olecranon Graft (n = 25)	Operative Extremity (Degrees)	Nonoperative Extremity (Degrees)	*P*
Elbow extension	2 (5)	2 (5)	0.38
Elbow flexion	143 (5)	143 (4)	0.66

Measurements are recorded as mean (SD).

Table 4. Comparisons of Joint Motion Between the Operative and Nonoperative Extremities After Bone Graft Harvesting from the Distal Radius

Distal Radius Graft (n = 19)	Operative Extremity (Degrees)	Nonoperative Extremity (Degrees)	*P*
Wrist extension	66 (10)	66 (8)	0.94
Wrist flexion	74 (10)	74 (9)	0.94
Wrist radial deviation	23 (6)	23 (6)	0.84
Wrist ulnar deviation	37 (10)	38 (9)	0.51

Measurements are recorded as mean (SD).

cohort who failed to demonstrate bone healing had undergone grafting to fill a distal phalanx void resulting from curettage of a benign lesion. At the latest follow-up evaluations, no patients had undergone additional surgery to promote bone healing.

Complications

One patient from the OP group who received gelfoam in the graft harvest void developed a superficial wound infection at this site. The infection resolved with oral antibiotic treatment. One patient from the DR group who had had cancellous allograft packed into the graft harvest void experienced a wound dehiscence at this site that healed with topical wound measures. There were no significant differences in complication rates between cases with gelfoam or cancellous allograft inserted into the bone harvest void in comparison with cases without a bone void filler ($P = 0.46$). There were no cases in either group of a donor-site hematoma or fracture.

DISCUSSION

Varied techniques of bone extraction from the OP and the distal end of the radius have been described, including removal of corticocancellous pieces, trephination with withdrawal of corticocancellous plugs, curettage of cancellous bone through a cortical hole, and creation of a temporary cortical lid with curettage of cancellous bone.[1,7–27] The reported sizes, shapes (rectangular, elliptical, wedge, tear-drop), and positions of the cortical holes at each site have differed among authors. In addition, methods for harvesting bone from the DR have included both dorsal and volar exposures.[8–11,25] Nevertheless, the amount of available packed cancellous bone from both sites is comparable (2–3 cm^3).[7,8]

The OP and the DR bone graft harvesting techniques utilized in our study were consistent and involved making an oval-shaped cortical window that measured 1 cm or less in maximum dimension. The hole in the OP was positioned approximately 1 fingerbreadth distal to the tip of the process and proximal to the midpoint of the greater sigmoid notch (ie, proximal to the coronoid process). Anderson et al[7] performed a biomechanical study of 2 cortical penetration sites in the OP and commented that the quality of cancellous bone diminished distal to the coronoid process. The hole in the DR in our patients was made proximal to the tubercle of Lister and provided adequate exposure to abundant cancellous bone in the radial styloid process.[8]

Patient satisfaction was high with both olecranon and DR bone graft harvesting in our experience. In addition, there were no differences in active elbow motion (OP group) or wrist motion (DR group) between the operative and the nonoperative limbs. Nearly all graft recipient sites healed using either bone graft source and with limited donor-site complications, in agreement with other authors.[1,9–17,19–23,25,27] Early postoperative complications included 1 superficial wound infection in the olecranon bone graft harvest group and 1 wound dehiscence in the DR bone graft harvest group; both problems resolved without additional surgery. There was no clear relationship between the occurrence of these complications and the insertion of either gelfoam or cancellous allograft into the harvest void.

The presence of a palpable defect and/or a radiographic defect at the graft donor site was more common in patients who underwent harvesting from the OP; however, this was of dubious clinical relevance. There were no significant differences in harvest-site pain or swelling between the OP and the DR bone graft harvesting groups, few patients in either group with tenderness over the graft harvest site, and no cases of donor-site hematoma or fracture. Radiographic defects in the OP after graft harvesting have been previously reported, including examples of gradual corticocancellous bone remodeling.[9,15]

McGrath and Watson[9] reviewed 19 cases of bone grafting from the proximal ulna and 78 cases of bone grafting from the distal end of the radius and reported transient tenderness over the distal radial donor site in 1 patient. Ozcelik et al[15] reported 1 donor-site hematoma in 11 cases of olecranon bone grafting for the treatment of distal phalanx nonunions, and Mersa et al[14] reported 1 donor-site hematoma in 48 patients treated with olecranon bone graft-

ing for reconstructive procedures in the hand. Patel et al[11] reviewed 1670 DR bone graft cases and found an overall 4% incidence of complications, including donor-site fracture (0.1%), radial sensory neuroma (0.1%), and de Quervain tenosynovitis (1.3%). Mirly et al[10] reported 1 fracture in 131 DR graft harvest cases, all of whom had gelfoam inserted into the bone graft harvest void. No use of donor void filler was reported in the other 3 series.

Surgeons unfamiliar with the OP as a bone graft source may have concerns regarding the potential for donor-site fracture. We are aware of only 2 publications (3 cases) of olecranon fracture after graft harvesting.[24,26] The dimensions of the cortical windows in the OPs were recorded in 2 of these cases (1.5 by 2 cm^2 and 0.8 by 2.5 cm^2), and the location of the defect was described in 1 case (3.8 cm distal to the olecranon tip).[26] Several authors have reported removal of a comparable amount of bone from the OP and without fracture.[9,12,14] Furthermore, the OP has gained support among maxillofacial surgeons as an effective structural graft source with few and transient donor-site complications, including wound seroma and forearm paresthesias.[19,21,22,27]

Limiting the size of a cortical hole and making an oval or circular-shaped defect rather than a square entry point in bone may conceivably reduce the risk of iatrogenic fracture with bone graft harvesting. Edgerton et al[28] found that an increase in the size of a circular defect in sheep femora correlated inversely with the torsional strength of bone. Clark et al[29] reported that oblong holes with rounded ends in cadaver femora afforded the greatest residual strength of bone compared with rectangular holes with square or rounded corners. In addition, they noted that increasing the width of a cortical hole caused a significant reduction in strength, whereas increasing the length did not. De Camargo et al[30] found that square and circular shapes of cortical holes in dog femora had comparable resistance to torsional forces. Nonetheless, these authors suggested making holes with rounded rather than acute corners given the potential for increased tension with angularities. Specific to the DR, harvesting less than 25% of the total available metaphyseal cancellous bone may prevent alteration in load characteristics.[31]

There were recognized limitations with our retrospective study design that may have affected our findings and conclusions. The outcome assessments and x-rays of the graft donor sites were obtained at differing time points in the 2 study groups. The surgeons who performed the operations were involved in data collection and/or analysis, which may have introduced bias.[32] Our VAS questionnaire was not validated; consequently, we cannot conclude with certainty what differences in VAS scores (ie, minimal clinical important differences) are inarguably meaningful. Although patient-reported outcome measures were not significantly different between groups, this does not connote they were the same for both donor sites.

The volumes of cancellous bone harvested and the sizes of the resultant intramedullary defects were not quantified. The potential adverse effects of larger donor-site defects on postoperative complications could not be assessed. We did not order bone density tests before graft harvest; accordingly, poor quality bone in some cases may have adversely affected remodeling at the graft harvest sites and healing at the graft recipient sites. The graft recipient sites varied between groups, precluding a valid comparison of donor-site efficacy in stimulating bone healing. Finally, the insertion of gelfoam or cancellous allograft into the harvest voids was not consistently performed.

The location of the bone graft recipient site in the upper extremity may influence the combined surgeon and patient decision process on a suitable autograft source. Based on the results of this study, harvesting bone graft from the OP or the distal end of the radius through a small, oval-shaped cortical window is comparatively safe with minimal donor-site morbidity. Patient satisfaction with either graft harvest technique is projected to be very high at a minimum of 4 months after surgery.

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