



# Treatment of Neer type 4 impacted valgus fractures of the proximal humerus with open reduction, elevation, and grafting

## *Valgus impakte Neer tip 4 humerus üst uç kırıklarında açık redüksiyon, yükseltme ve greftleme*

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**Amaç:** Valgus impakte Neer tip 4 kırıklı hastalarda minimal invaziv açık redüksiyon, yükseltme ve greftleme yöntemiyle cerrahi tedavinin klinik ve radyografik sonuçları değerlendirildi.

**Çalışma planı:** On hastanın (6 kadın, 4 erkek; ort. yaş 54; dağılım 35-67) valgus impakte Neer tip 4 humerus üst uç kırığına açık redüksiyon, baş yükseltme, greftleme, tüberküllerin dikişle tespitinden oluşan biyolojik rekonstrüksiyon uygulandı. Hastaların, hepsi ameliyat öncesinde bilgisayarlı tomografi ile değerlendirildi. Olguların üçünde krista iliyakadan alınan trikortikal greft kullanılırken, yedi hastada liyofilize trikortikal iliyak allogreft kullanıldı. Cerrahi girişim travma sonrasında ortalama üçüncü günde (dağılım 1-10 gün) yapıldı. Hastalar radyografilerle ve fonksiyonel olarak Constant ve DASH (disabilities of the arm, shoulder and hand) skorları ile değerlendirildi. Ortalama takip süresi 38.8 ay (dağılım 24-49 ay) idi.

**Sonuçlar:** Kırık kaynaması 6-8 haftada gerçekleşti. Son kontrollerde omuz öne elevasyonu ortalama 154° (dağılım 120°-175°), dış rotasyon 44° (35°-55°) bulundu. Ortalama Constant skoru 81.5 (dağılım 72-90), ortalama DASH skoru 23 (dağılım 17-38) olarak belirlendi. Radyografik olarak ameliyat öncesinde ortalama 178° (170°-200°) olan humerus başı inklinasyon açısı ameliyat sonrasında 134° (130°-145°) ölçüldü. Hiçbir olguda humerus başında avasküler nekroz bulgusu saptanmadı. Tüm hastalar sonuçtan memnundu.

**Çıkarımlar:** Valgus impakte Neer tip 4 humerus üst uç kırığı olan seçilmiş hastalarda, greftle mekanik destek de içeren biyolojik rekonstrüksiyon yöntemi etkili bir tedavi seçeneği olabilir.

**Anahtar sözcükler:** Kırık tespiti, internal; humerus kırığı/cerrahi; omuz kırığı; cerrahi prosedür minimal invaziv.

**Objectives:** We evaluated the clinical and radiographic results of minimal invasive surgery, with elevation of the head and tricortical iliac grafting for Neer type 4 impacted valgus fractures.

**Methods:** Ten patients (6 females, 4 males; mean age 54 years; range 35 to 67 years) with Neer type 4 impacted valgus fractures of the proximal humerus underwent biological reconstruction including open reduction, elevation of the head fragment, grafting, and suture fixation of tuberosities. All the patients were assessed by computed tomography preoperatively. Tricortical iliac crest autograft was used in three patients and lyophilized iliac allograft was used in seven patients. The mean time to surgery was three days (range 1 to 10 days). Radiographic and clinical results were evaluated after a mean follow-up of 38.8 months (range 24 to 49 months). Constant and DASH (disabilities of the arm, shoulder and hand) scores were used for functional evaluation.

**Results:** All the fractures united within six to eight weeks. On final examinations, the mean forward flexion of the shoulder was 154° (range 120° to 175°) and external rotation was 44° (35° to 55°). The mean Constant and DASH scores were 81.5 (range 72 to 90) and 23 (range 17 to 38), respectively. The mean inclination angle of the humerus head decreased from 178° (170°-200°) to 134° (130°-145°) postoperatively. None of the patients had signs of osteonecrosis in the humeral head. All the patients were pleased with the outcome.

**Conclusion:** The biologic reconstruction technique used with graft support may be an effective alternative treatment in selected patients with type 4 valgus impacted fractures of the proximal humerus.

**Key words:** Fracture fixation, internal; humeral fractures/surgery; shoulder fractures; surgical procedures, minimally invasive.

Treatment of proximal humerus fractures are still controversial. Most demanding part of this issue is the treatment of Neer Type IV fractures.

The perfusion of the humeral head is the most reliable predictive factor for Type IV fractures in Neer classification. According to previous investigations, the main blood supply of the humeral head arises from the anterolateral ascending branch of the anterior humeral circumflex artery (ACA), and from the inter-osseous branch of (ACA), the arcuate artery.<sup>[1]</sup> Avascular necrosis is relatively uncommon with four-part, impacted valgus fractures versus other four-part fractures.<sup>[2]</sup> For Neer Type III to IV fractures and fracture dislocations on elderly people and for split fractures of the humeral head, and Neer Type IV fracture dislocations on young people, shoulder hemiarthroplasty is generally the best choice of treatment.<sup>[3,4]</sup> Minimal (less) invasive procedures, with minimal dissection are essential to maintain the perfusion of the fracture fragments. In a prospective cohort design, we investigated the results of minimal invasive surgery, with elevation of the head and tricortical iliac grafting for Neer Type IV impacted valgus fractures. The results were evaluated in respect of the perfusion of the head fragment, clinical shoulder scoring and permanence of the anatomical reduction.

### Patients and methods

Ten (four male and six female) patients with Neer Type IV impacted valgus fracture were treated with the same operative technique by the same surgeon between 1999 and 2003 in our institution. Trauma series radiographs (antero-posterior, axillary and scapula tangential) and computerized tomography of the shoulder were obtained from all of the patients.

Patients were selected with the following criteria:

1. Physically and mentally active persons
2. No major systemic disease or any other major trauma.
3. If the humeral head fragment tilted in valgus direction and tuberosity fragments were displaced as described by Jakob et al.<sup>[2]</sup>
4. The angle between humeral diaphysis and the line perpendicular to the articular surface (humeral head inclination angle)<sup>[5]</sup> should be more than 170 degrees.

Patients who were not eligible for this treatment were: 1.Low demanded elderly (>70 years); 2. Patients with severe cardiovascular and/or pulmonary diseases which may complicate anesthesia; 3.Low cooperation for the postoperative rehabilitation period because of dementia or other psychiatric disorders.

Average age of the group was 54.4 years (range 35 to 67 years). Cause of the trauma was traffic accident in three patients, falling injury in the other seven. None of the patients had an open wound, neurovascular injury or any other fracture at the time of presentation. Surgeries were performed on the 1st to 10th (mean 3rd) day after the initial injury. (Table 1)

### Surgical technique

All the procedures were conducted under general anesthesia in the "Beach-chair" position. A deltopectoral approach was used with a 5 to 6 cm straight incision. The fracture line with impaction which had been detected on preoperative CT images was exposed. The split between the tuberosities was identified and spread to allow access to the humeral head. The rotator interval was exposed and glenohumeral joint space was examined and any intra-articular free fragment, if existed, was removed. The fracture parts were not dissected from adjacent soft tissues.

The central part of the head fragment was drilled with a thin Kirschner wire (1,5 mm) to evaluate blood circulation. If visible blood flow from the hole was observed, humeral head was considered as viable and the procedure was continued. But if bleeding would not occur, from three

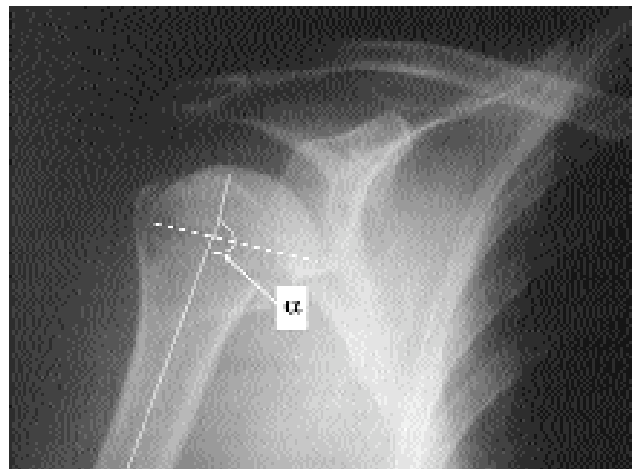


Figure 1. Humeral head inclination angle ( $\alpha$ : 185°).

**Table 1.** Demographics of patients

Pat #	Age/Sex years	Side	Trauma	Graft	Follow-up (months)
1	54/F	L	Fall	Auto	46
2	57/F	R	Fall	Auto	44
3	54/F	R	Fall	Allo	47
4	36/M	R	Road acc	Auto	40
5	35/M	R	Road acc	Allo	41
6	65/F	L	Fall	Allo	49
7	65/F	L	Road acc	Allo	41
8	67/F	R	Fall	Allo	30
9	51/M	R	Fall	Allo	26
10	60/M	L	Fall	Allo	24

drill holes in different parts of the head, the procedure would be switched to prosthetic replacement. Such situation did not happen in any of these ten cases, humeral head was viable in all patients.

No retractor was applied from the medial side of the humeral neck and greatest care was given to preserve the integrity of the medial hinge during reduction. The humeral head was elevated and reduced to its anatomical position with a blunt dissector. The augmentation created a cavity under the head that required to be filled and supported mechanically to prevent a subsequent collapse. Tricortical iliac crest bone grafts were used for this purpose. Autogenous grafts were harvested from their own iliac crest three patients. Lyophilized iliac crest allografts were used in seven cases (Figure 1). In three patients treated with autografts, donor site morbidity (pain, swelling and slight limping) was an important problem. We used allograft with identical shape and size in other patients, to anticipate donor site problems. Stabilization by internal fixation of both tuberosities and humeral diaphysis were achieved with tension devices: wiring in one patient, suturing in the other nine. Number-5 non-absorbable Ethibond sutures were used before 2003, presently "Fiberwire (Number-2 and 5)" are preferred. Fracture reduction and position of the head fragment were evaluated under image-intensifier control. In one case, following elevation of the humeral head, the resultant medial cortical insufficiency necessitated additional fixation of the lateral cortex to the head fragment with 4 threaded Kirschner wires, which

were removed at the end of the 6th week after the operation (Figure 2).

All patients had worn a shoulder sling for four weeks post-operatively. Electric stimulation for deltoid, isometric deltoid and passive range-of-motion exercises were started after the operation and continued for three weeks, followed by phase II active-assisted range-of-motion exercises. Resisted strengthening exercises were started following the radiological signs of bone union in the six to eight weeks after the operation.

In the follow-up visits, patients were assessed radiologically with the three trauma series radiographs and functionally with Constant<sup>[6]</sup> and DASH<sup>[7]</sup> scores of all patients were assessed.

## Results

The mean follow-up time was 26.8 (12-37) months. No intraoperative or postoperative complication (infection, nerve impairment etc.) had occurred.

### Radiographic assessment:

Average humeral head inclination angle was measured preoperatively 178° (range 170 to 200°). Inclination angle improved in early postoperative radiographs to an average value of 134° (range 130 to 145°). Same inclination angles were observed in last follow-up. The follow-up x-rays revealed that glenohumeral joint congruity, anatomical reduction of the greater tuberosity. Fracture healing was observed between 6 to 8 weeks after the operation.

None of the patients had signs of osteonecrosis in the humeral head.

### Range of motion

On the last clinical control, the average forward flexion of the shoulder was 154° (range, 120° to 175°) and the average external rotation was 44 (range 30° to 55°) (Figure 3).

### Constant score

The median Constant score was 81.5 (72-90) and subgroups of Constant score was summarized in Table 2. Median value of pain score was 14 out of 15, three patients had mild pain with activities and remaining seven patients reported no pain.

### DASH score

Functional assessment of the patients with DASH score revealed a mean score of 23 (17-38). All patients were satisfied with their end clinical status. Two male patients, younger than 40 years, returned their office jobs after two months. Other patients, who are retired and housewives and had no significant difficulty in their daily activities.

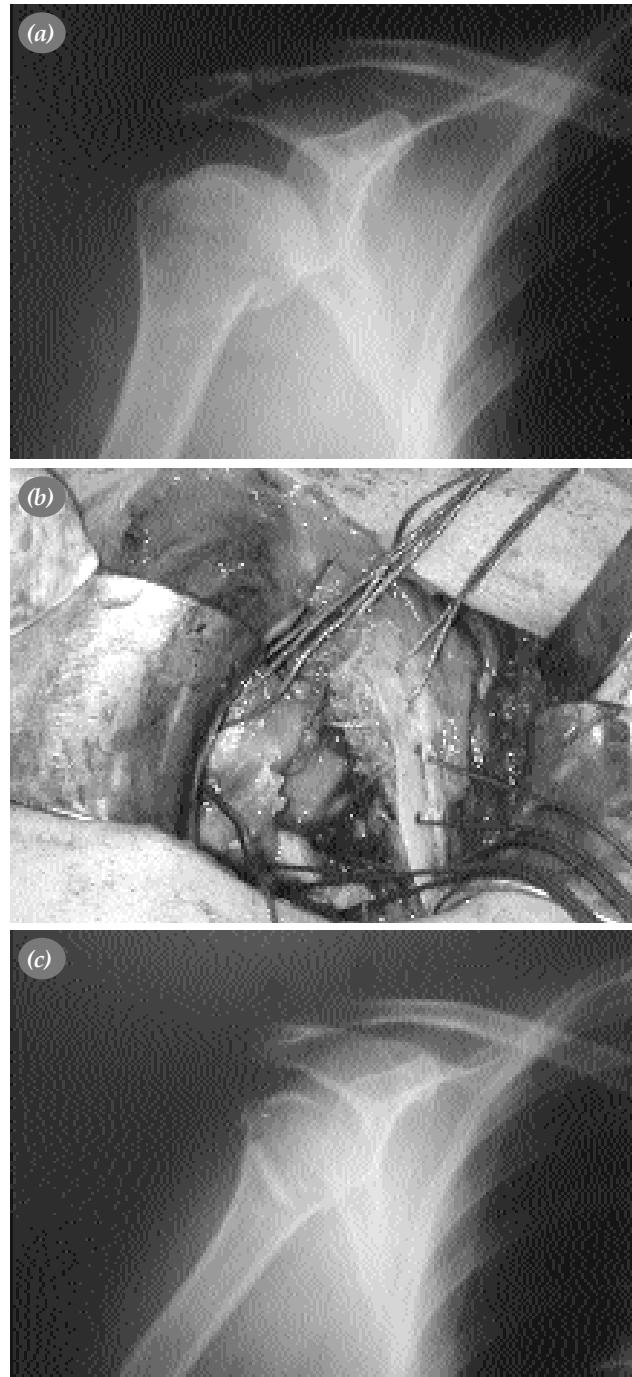
### Discussion

Most fractures of the proximal part of the humerus where the bone is minimally displaced can be treated with nonoperative techniques.<sup>[3]</sup> However there is still controversy about the treatment of fractures which require surgical intervention. Type III and IV fractures according to Neer Classification are the most difficult ones to treat and their expected clinical results are the least successful. With the vascular anatomy of the proximal humerus in mind, Arcuate artery injury is not likely to occur in impacted valgus fractures. As a matter of fact, in valgus impacted Type IV fractures, the avascular necrosis rate is only 26%<sup>[2]</sup>, a relatively low percentage.<sup>[8,9]</sup> In a study about the factors influencing the perfusion of the humeral head, it was shown that the perfusion of the head is better in valgus impacted fractures compared to the other types of fracture, especially if displacement of the medial hinge is less than 2 mm.<sup>[10]</sup>

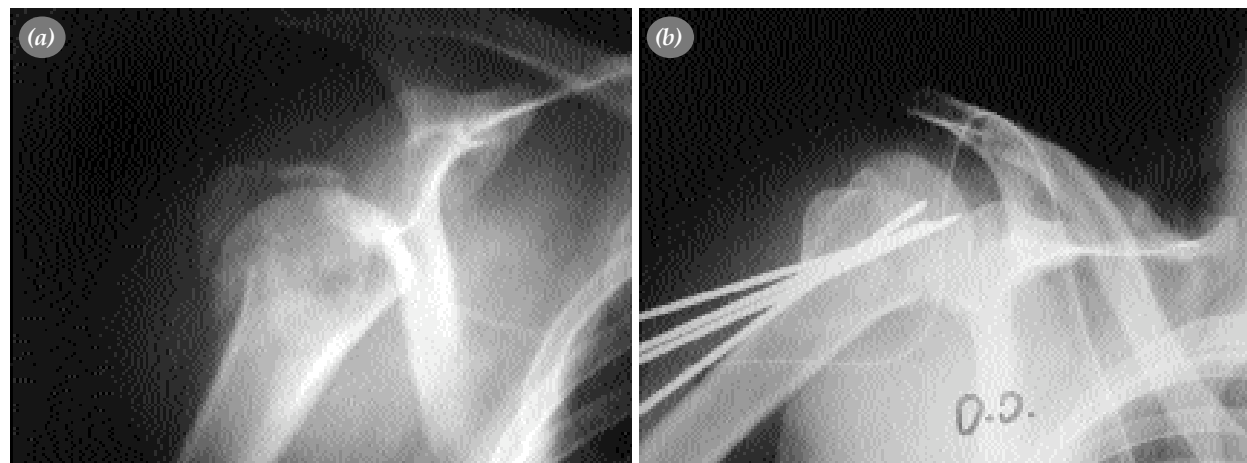
Hemiarthroplasty is generally the treatment of choice for patients above 60 years of age. Although hemiarthroplasty is successful for the relief of pain, the functional results of the procedure are not satisfactory.<sup>[4,11,12,13]</sup> In addition, cost and technical difficulties pertaining to the prosthetic surgery has led surgeons to seek other solutions than hemiarthroplasty. In recent studies, conservative treatment was also offered as an option for elderly patients with relatively less functional expectations, especially for those with type III fractures.<sup>[14,15]</sup> A retrospective study of 125 valgus impacted (AO type B1.1) fracture patients managed without surgery revealed low Constant scores compared to our results.<sup>[16]</sup>

Though the result of probable secondary hemiarthroplasties will be less successful,<sup>[17,18]</sup> osteosynthesis with minimal invasive techniques should be

tried in young patients with Type IV valgus impacted fractures.<sup>[9, 19]</sup>



**Figure 2.** (a) Preoperative radiograph of male patient with age 35 years. (b) Iliac crest allograft placed under elevated head fragment. (c) Control radiograph after six months postoperatively showing fracture healing without loss of reduction



**Figure 3.** (a) Preoperative radiograph of male patient with age 51 years. (b) Postoperative radiograph, showing anatomic reduction and additional K-wire osteosynthesis.

In this fracture, humeral head rotates on a pivot point on the medial part of the anatomical neck and collapses onto the diaphyses, so it requires to be elevated and supported in its anatomical position. Consequently, in a series of patients operated with minimally invasive osteosynthesis, secondary displacement of the fracture was reported due to the metaphyseal defect under the humeral head.<sup>[20]</sup> Secondary lost of fixation had been reported in a series, where cancellous graft was used to fill the defect after humeral head reduction<sup>[21]</sup> Therefore to avoid such complication, we used grafts to provide both mechanical and biological support.

Obviously, using autogenous grafts from the patient may cause donor site morbidity. Allografts with same shape and size had helped us to prevent donor site problems and shortened operation time.

A study where the defect was fixed with screw and filled with bone cement instead of bone grafts, revealed similar results with our series.<sup>[22]</sup> In the same study, after the reduction of the humeral head, the resulting bone defect required 8 mL of “Norian SRS bone cement” injection in average. Tuberosities sutured strongly with bone sutures to the underlying bone graft provide adequate stabil-

**Table 2.** Outcome scores of patients

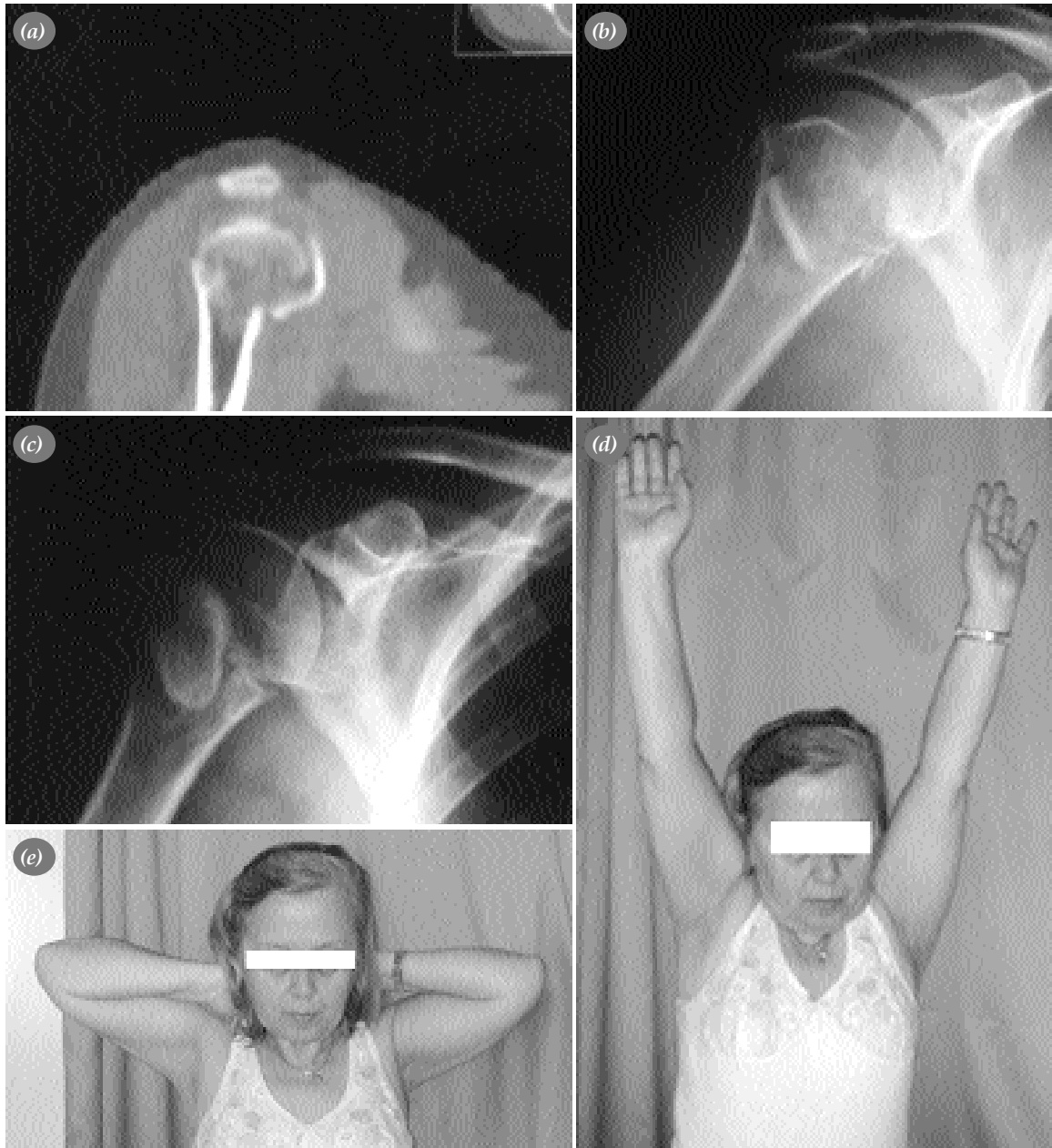
Pat #	Overall Constant	Constant Pain	Constant ROM	Constant ADL	Constant Strength	DASH
1	80	15	34	16	15	24
2	82	14	32	14	22	23
3	72	13	25	16	17	38
4	80	12	32	17	19	23
5	81	12	35	14	20	17
6	90	15	37	20	18	20
7	88	14	35	18	21	23
8	77	11	30	16	20	31
9	88	14	35	17	22	22
10	90	15	36	16	23	21

ROM: Range of motion; ADL: Activities of daily living; DASH: Disability arm shoulder hand.

ity without the need for any osteosynthesis material.<sup>[21,23]</sup>

Although the number of our cases is few, minimally invasive reduction with elevation of the head fragment and supporting the head fragment with tricortical iliac graft seems to be an effective

alternative treatment method for Type IV valgus impacted fractures of the proximal humerus. Tricortical iliac crest grafts are a suitable choice in that they are biological and they provide optimal mechanical support for the humeral head with strong fixation of the tuberosities.



**Figure 4.** (a) Preoperative CT showing valgus impacted fracture of female patient with age 54 years (b) Early postoperative and (c) two years postoperative radiographs showing anatomic reduction of fracture. (d) Her actual forward flexion and (e) external rotation of shoulder.

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