ARAŞTIRMA MAKALESİ / *RESEARCH ARTICLE*

The Effect of Abdominal Subcutaneous Fat Tissue Thickness in Pelvic Trauma

Abdominal Subkutan Yağ Doku Kalınlığının Pelvik Travma Üzerine Etkisi

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ABSTRACT

Aim: *Obesity is a very important health problem throughout the world. The effect of obesity on trauma-related injuries is being investigated in contemporary literature. The weight of the patient is said to increase complications with the severity of trauma. The effect of obesity on pelvic trauma has been investigated in various studies in the literature. However, no similar study investigating the effect of obesity on acetabular fractures and accompanying femoral head fractures has been found.*

Our aim in this study is to determine the incidence of accompanying femoral head fractures in adult cases with acetabulum fracture and to investigate whether abdominal subcutaneous fat tissue thickness has an effect on this co-existence.

Material and Method: *Pelvic CT scans taken in our hospital due to trauma were retrospectively reevaluated and cases with acetabulum fracture were detected. These cases were divided into two separate groups: those with isolated acetabulum fractures and those with acetabulum-and accompanying femoral head fractures. Abdominal subcutaneous fat tissue thicknesses of all cases were measured via CT scan. It has been investigated whether there is a statistically significant difference between the two groups in terms of subcutaneous fat tissue thickness.*

Results: *A total of 95 acetabular fractures were detected. In 22 cases (23.2%), femoral head impaction fracture was present in addition to acetabulum fracture. In the remaining 73 cases (76.8%), the femur head was normal. The average abdominal subcutaneous fat tissue thickness was 24.4 (±9.2) mm in isolated acetabular fracture cases, and 30.4 (±8) mm in cases with acetabulum and accompanying femoral head fractures. Abdominal subcutaneous fat thickness was significantly higher in patients with femoral head fracture in addition to acetabulum (p=0.006).*

Conclusion: *It's possible to say that abdominal subcutaneous fat accumulation increases the risk of femoral head fracture development by increasing the severity of trauma, thus increasing the morbidity.*

Key words: *acetabulum; femur fracture; subcutaneous fat*

ÖZET

Amaç: *Obezite dünya genelinde çok önemli bir sağlık problemidir. Güncel literatürde travmalara bağlı hasara obezitenin etkisi araştırılmaktadır. Hasta kilosunun, travmanın şiddeti ile beraber komplikasyonları arttırdığı söylenmektedir. Obez hastalarda travma sonrası ekstremite kırıklarının daha sık görüldüğü öne sürülmektedir. Literatürde pelvik travmalara obezitenin etkisi çeşitli çalışmalarla araştırılmıştır. Ancak asetabuler fraktür ve eşlik eden femur başı fraktürlerine obezitenin etkisini araştıran benzer bir çalışma bulunamamıştır.*

Bu çalışmada amacımız; asetabulum fraktürü olan erişkin olgularda, eşlik eden femur başı fraktürünün görülme sıklığını belirlemek ve bu birlikteliğe abdominal subkutan yağ doku kalınlığının etkisi olup olmadığını araştırmaktır.

Materyal ve Metot: *Travma nedeniyle hastanemizde çekilen pelvik tomografiler retrospektif olarak yeniden değerlendirilerek, asetabulum fraktürü olan olgular saptandı. Bu olgular, izole asetabulum fraktürü olanlar ve asetabulum ile femur başı fraktürü birlikte görülenler olarak iki ayrı gruba ayrıldı. Tüm olguların abdominal subkutan yağ doku kalınlıkları tomografik olarak ölçüldü. İki grup arasında subkutan yağ doku kalınlığı açısından istatistiksel anlamlı farklılık olup olmadığı araştırıldı.*

Bulgular: *Toplam 95 olguda asetabuler fraktür bulundu. Olguların 22'sinde (%23,2) femur başı impaksiyon fraktürü eşlik etmekteydi. Kalan 73 olguda (%76,8) femur başı normaldi. Ortalama abdominal subkutan yağ doku kalınlığı; izole asetabuler fraktür olan olgularda 24,4 (±9,2) mm, eşlik eden femur başı fraktürü olan olgularda 30,4 (±8) mm idi. Abdominal subkutan yağ doku kalınlığı, femur başı ve asetabulum fraktürü birlikte görülen olgularda istatistiksel olarak anlamlı derecede daha fazlaydı (p=0,006).*

Sonuç: *Asetabulum fraktürüne ek olarak femur başı fraktürü izlenen olgularda abdominal subkutan yağ doku kalınlığı belirgin daha fazla bulunmuştur. Abdominal subkutan yağ birikiminin, travmanın şiddetini arttırarak femur başı fraktürü gelişimi riskini, dolayısıyla morbiditeyi arttıran bir risk oluşturduğu söylenebilir.*

Anahtar kelimeler: *asetabulum; femur fraktürü; subkutan yağ*

Introduction

The pattern and severity of a post-traumatic injury depend on the complex relationship between biomechanical factors such as the velocity of trauma, the use of decelerators (e.g. seat belts), and the intensity of the

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impact. In addition, characteristics such as height and weight of the human body play an important role[1]. The effect of body mass on the traumatic injury pattern was assessed through different studies for adults and children. The general conclusion of these studies is that obesity is predisposed to various injury patterns but does not necessarily increase the cumulative severity of the injury[2–5]. Some studies, on the contrary, suggest that a high body mass index (BMI) increases the energy dispersed during trauma, thereby increasing the risk of injury and death in severe traumas[6].

The incidence of hip fractures has increased over the last decades[7]. Although the cause of this increase is not known, it can be explained in part by a more sedentary lifestyle and a change in the weight-bearing parts of the thigh bones[8]. Acetabular fractures have been reported in about 50% of femoral head fractures[9]. Femoral head fractures can lead to severe morbidity and multiple complications such as avascular necrosis, osteoarthritis, peripheral nerve damage, heterotopic bone formation[10]. The incidence of femoral head fracture in acetabulum posterior wall fractures is between 18 and 63%. The overall incidence of both femoral head and acetabulum fractures has been reported to be 11% after excluding posterior wall fractures. In acetabular fractures associated with femoral head fractures, hip arthroplasty is more commonly needed[11]. There are several publications in the literature investigating the coexistence of femur head and acetabular fractures. To our knowledge, however, there is no similar study investigating the effect of obesity on the rate of femoral head fracture accompanying to acetabular fractures.

The purpose of this study is to investigate whether subcutaneous fat tissue thickness has an effect on the rate of femoral head fracture in trauma patients. The study examined whether the frequency of accompanying femoral head fracture changes as the subcutaneous fat tissue thickness increases in cases with acetabular fractures.

Material and Method

Ethics

This study has been approved by the ethics committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Study design

Computerized tomography (CT) scans of patients who applied to our hospital due to trauma between June 2017 and November 2017 were retrospectively reevaluated. Adult cases with acetabular fracture in pelvic CT were included in the study. Abdominal subcutaneous fat tissue thickness of all acetabular fracture cases was measured from axial sections. The measurement was performed as standard, 5 cm lateral to umbilicus, bilaterally, and in millimeters (Figure 1). The arithmetic mean of the values from the right and left measurements was calculated[12].

Figure 1. *Axial CT image, the measurement was performed as standard, 5 cm lateral to umbilicus (continuous lines), bilaterally, and in millimeters. The arithmetic mean of the values (dashed lines) from the right and left measurements was calculated.*

Among the cases with acetabular fractures, those with accompanying femoral head fractures were noted. Patients were divided into two separate groups: cases with isolated acetabulum fractures and cases with acetabulum-and accompanying femoral head fractures. Statistical analysis was performed to investigate the presence of a difference in abdominal subcutaneous fat tissue thickness between the two groups.

In addition, all acetabular fractures were typologized according to the Judet-Letournel classification and the most common types of fractures were identified. Pediatric cases were excluded from the study.

Imaging parameters

All CT scans were performed using the same 128-slice CT device (Optima CT660, General Electric Healthcare Systems, Milwaukee, USA), at a dose appropriate for the bone structure, with sections of 2.5 mm thickness and according to the standard imaging protocol. Axial, coronal and sagittal images as well as three dimensions (3D) reconstructed images were evaluated by a radiologist with 10 years of tomography experience in the same workstation.

Statistical analyses were performed using Statistical Package for the Social Sciences 15.0 (SPSS Inc. ; Chicago, IL, USA). Non-parametric parameters were analyzed using the Mann-Whitney U test. It was confirmed when a binary logical regression analysis was carried out. Data were shown as mean ± standard deviation or median (min-max), where applicable. A p value <0.05 was considered statistically significant.

Results

As a result of pelvic CT scans taken between June 2017 and November 2017, a total of 95 acetabular fractures were detected. The ages of the patients ranged from 18 to 88 (mean: 48.2). 36 of them were female (38%) and 59 were male (62%). All the cases had a motor vehicle trauma. The average abdominal subcutaneous fat tissue thickness of all cases was 25.8 mm.

In 22 cases (23.2%), femoral head impaction fracture was present in addition to acetabulum fracture. The ages of these 22 patients ranged from 37 to 85 (mean: 49.6). 18 of them were male. 12 of femoral head-and acetabulum fractures were on the right side and 10 of them on the left side.

The average abdominal subcutaneous fat tissue thickness was 24.4 (±9.2) mm in isolated acetabular fracture cases, and 30.4 (±8) mm in cases with acetabulum and accompanying femoral head fractures. Abdominal subcutaneous fat thickness was significantly higher in patients with femoral head fracture in addition to acetabulum ($p<0.05$). When two groups were compared for the age there was not any significant difference ($p=0.56$).

Baseline characteristics of patients with and without femoral head fracture summarized in Table 1.

All acetabular fractures were typologized according to the Judet-Letournel classification (Table 2). The most common types according to this classification were

Table 1. *Baseline characteristics of patients with and without femoral head fracture*

	Femoral head fracture present (n=22)	Femoral head fracture absent (n=73)
Age (mean ± SD)	49.6±18.6	48.2±21.4
Gender, n (%) (male/female)	18 (81.8%)/4 (18.2%)	45 (61.6%)/28 (38.4%)
Mechanism of injury, n (%)		
Hit a pedestrian	9 (40.9%)	42 (57.5%)
Multiple vehicle collisions	7 (31.8%)	23 (31.5%)
Single-car accidents	6 (27.3%)	8 (11%)

Table 2. *The distribution of all acetabular fractures according to the Judet-Letournel classification and location, and accompanying femoral head fracture frequency*

	Femoral head fracture (+)	Femoral head fracture (-)	Total
Judet-Letournel Classification	n=22	n=73	n=95
Anterior wall	0	13	13
Anterior column	1	29	30
Posterior column	0	6	6
Posterior wall	4	5	9
Transverse fracture	2	2	4
T shape fracture	2	2	4
Transverse + posterior wall	1	2	3
Posterior column + posterior wall	0	2	2
Anterior column + posterior hemitransverse	3	2	5
Both columns	9	10	19
Acetabular Fracture Locations (%)			
Anterior (45.3%)	1	42	43
Posterior (15.8%)	4	11	15
Complex (38.9%)	17	20	37

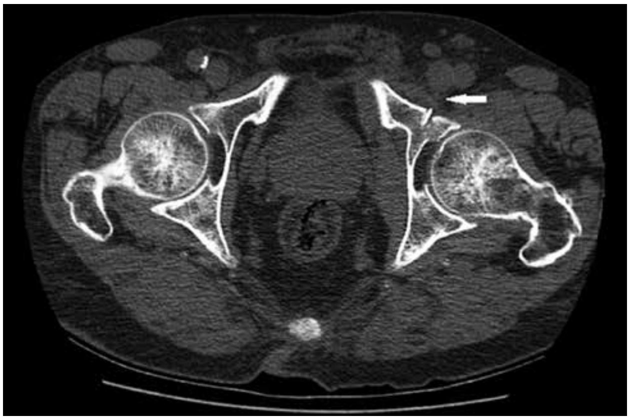

Figure 2. *Axial CT image of the anterior column fracture (white arrow), one of the most common fracture types, when our cases were evaluated according to the Judet-Letournel classification.*

Figure 3. *3D reconstruction image of double column fracture, with break in obturator ring and extension into iliac wing.*

fractures in anterior column (31.6%) and both columns (20%). When assessed independently from the subcutaneous fat tissue thickness, the ratio of acetabular fractures accompanied by femoral head fracture was higher in combination types affecting both the anterior and posterior columns and in the types affecting only the posterior column. In the acetabular fracture types affecting the anterior column, the coexistence rate of femoral head fracture was significantly lower and the difference was statistically significant.

Figures 2, 3 and 4 show CT images of the sample cases.

Figure 4. *In the axial image passing through the acetabulum level, fracture at the femoral head (open arrow) in addition to the acetabulum fracture.*

Discussion

Obesity is a chronic metabolic disease that becomes epidemic and is a major health problem worldwide[13–15]. Due to its increasing prevalence, it is now accepted as a global pandemic[16–18]. According to NHANES (United States National Health and Nutrition Examination Survey) data for 2011–2012, more than one third of adults are obese[18]. With the worldwide increase in obesity, an important debate has started about whether its effect on skeletal health is destructive or beneficial[19].

Kim et al.'s[20] study reported that extremity fractures are significantly higher in obese children compared to non-obese children. Davidson et al.'s[21] study, on the other hand, revealed that the risk of upper extremity fracture in obese children was 1.7 times higher than in non-obese children. Besides, Pomerantz et al. [22] reported a significantly higher risk of lower extremity fracture in obese children. In a study conducted by Backstrom et al. [2] in 356 pediatric cases, a higher Injury Severity Score (ISS) values were reported in obese pediatric patients with lower extremity long bone fractures compared to non-obese patients. The same study observed more severe injuries and a higher Abbreviated Injury Scale (AIS) in each major body part (head and neck, chest, abdomen and extremities), and revealed that pelvic fractures and spinal column injury were more common in obese patients. Backstrom et al.'s study discovered that the obese patients have a greater need for operation in case of femoral fractures. A similar finding has been reported in Rana et al.'s[3] study of 1.314 pediatric trauma cases. It has been suggested that greater need for operation may indicate more severe fracture patterns.

In a study conducted on 149.817 pediatric cases, Witt et al. [23] reported that upper and lower extremity injuries were significantly more frequent, and that head, thorax, abdomen, and spinal injuries are observed less frequently in patients with a higher BMI. Another study conducted by Vaughan et al. [24] on 1.012 pediatric cases found that ISS and abdominal AIS were significantly higher in obese patients when compared to non-obese patients. In this study, severe hepatic damage was more common in obese patients, but there was no difference in terms of femoral fracture, costa fracture, pleural injury, and brain damage.

One reason for the more frequent occurrence of extremity fractures in obese children may be their higher exposure to risky situations in terms of trauma. Most of the studies found that bone mineral content was normal or increased in obese children[20,25]. However, the general opinion is that obese children have a relatively decreased bone mass compared to the bone size and body weight[20,26]. Dual energy X-ray absorptiometry (DEXA) studies have shown that obese children have a relatively low bone area and bone mass compared to their normal weight peers, although they have a higher absolute bone density considering their chronological age[26]. Increased kinetic energy associated with increased body mass can lead to more severe damage patterns[1,2]. An increased mass associated with obesity may lead to a higher energy and power dispersion in the lower extremities after trauma[27]. Larger individuals are at greater risk of injury, as the energy of the impact is directly proportional to mass and speed[15]. Furthermore, less or looser use of the seatbelt in obese children can cause more damage in case of motor vehicle accidents[2,27].

In adults, on the other hand, the findings differ from the children. According to the studies done on adults, the total body fat mass and the areal bone-mineral densitometry (BMD) measured by DEXA show a positive correlation[19]. Low weight or low BMI is a well-known risk factor for fracture development in the adult population. That is, there appears to be a protective effect of high BMI[20,28,29]. However, our results contradict with this view. According to our study, the increase in subcutaneous fat tissue thickness may have an effect on the development of femoral head fracture accompanied by acetabulum fracture.

A meta-analysis of 60.000 women and men, including twelve prospective community-based cohort studies, showed that total fractures, osteoporotic fractures and hip fractures were inversely related to BMI. In all fractures, age-related fracture irrespective of BMD was reported to increase with low BMI[29].

The study conducted by Arbabi et al. [1] on 189 adult trauma patients revealed that mortality and the severity of lower extremity injuries increased in obese patients. In this study, however, lower ISS and abdominal AIS scores were found in overweight patients. Based on this finding, the authors suggested that increased adipose tissue associated with obesity may cause dispersion of energy during trauma and may provide a protective effect against severe injury, especially in abdominal traumas (cushion effect). Conversely, according to our study, the increase in subcutaneous fat tissue thickness poses a risk for femoral head fracture development. In obese patients, the energy transfer and rate increase directly proportional to body weight at the time of trauma may explain the outcome of our study.

In the extensive community-based study conducted by Joakimsen et al. [30], low BMI was suggested to be a risk factor for low-energy fractures in middle-aged women and men. It has been reported that weight-gaining men have decreased hip fracture risk, while women who gain weight are reported to have decreased lower extremity fracture risk. The analyzes conducted in this study revealed that all low-energy fractures in women had a statistically significant relationship with BMI. In men, on the other hand, a similar relationship was identified, albeit not statistically significan. The weak protective effect of weight gain, which is reported by the study of Joakimsen et al., is also compatible with the work of Cummings et al. [31].

Recent studies suggest that the effect of obesity on bone fractures in adults may be specific to the body part. For example, although obesity appears to be protective for vertebral fractures, it has been reported to increase the risk of humeral fractures as well as ankle fracture frequency and severity[19,32,33]. However, it is unclear whether this is due to mechanical instability associated with the power increase or due to regional decline in bone mass associated with overweight[19].

BMI can affect fracture risk in different ways[30]. Body mass correlates positively with bone mass[30,34]. Even after the addition of the fracture risk measured by BMD, low BMI is a significant risk factor for hip fracture. Although the mechanism is not completely known, muscle weakness, protein or vitamin D deficiency, or reduced protective tissue around the large trochanter may be effective[29]. Besides, the body mass correlates with the amount of soft tissue that protects the skeleton structure. This correlation is particularly important for the hip[35]. Although this finding seems to contradict with our study, our study measured the subcutaneous fat thickness at the level of the anterior abdominal wall, not around the hip. Fat accumulation at the level of the abdomen or obesity may cause trauma-induced concussions or injuries occur with higher energy and with increased damage severity.

The authors suggest that this poor protective effect of weight gain is lost due to increased risk of cardiovascular disease, hypertension and diabetes[29,30]. Conducted studies also suggest that obesity may be associated with trauma-related mortality[15]. In other words, obesity is an independent risk factor for mortality and morbidity related to high-energy trauma[36]. Decrease in lung volume and compliance is more common in obese patients. Deep vein thrombosis, gastroesophageal reflux and insulin resistance are also more common[37]. Thus, obesity in trauma patients is reported to lead to increased complications[18]. The incidence of pulmonary and renal complications is higher in obese patients[36]. Obese trauma patients have a greater need for mechanical ventilation and a higher incidence of multiple organ failure, and they spend a longer time in intensive care[15,18]. Furthermore, some studies have suggested that trauma may exacerbate the side effects related to critical illnesses in obese patients by increasing the persistent inflammatory response[18]. Surgical procedures may become difficult and the diagnostic sensitivity of radiological imaging may be reduced due to obesity[37]. The study conducted by Ryb et al. [38] on 1.615 adult patients discovered that reported increased severity of damage in overweight patients. In a study of 382 adult patients, on the other hand, Morris et al. [36] have found that the risk of obesity-related complications increases significantly in trauma cases with operative and non-operative pelvic injuries. According to some authors, increased mortality is not due to higher trauma injury, but rather due to the more difficult post-traumatic care in obese patients and other comorbidities associated with obesity[1].

With all these factors in mind, patients should be advised to be normal weight. One should emphasize that leanness is a risk factor for hip fractures rather than focusing on the view that increased body fat content may be protective[29].

When evaluated in terms of location and independently from subcutaneous fat tissue thickness, fractures affecting posterior segment of acetabulum were more frequently accompanied by femoral head fracture and this finding is consistent with the literature.

Study limitations

Only adult cases were included in our study because of the inadequate number of pediatric cases. The small number of patients is also one of the limitations of our study. Furthermore, because the height and weight values of the patients were inaccessible, BMI could not be used as a comparison parameter. Therefore, we investigated the effect of abdominal subcutaneous fat tissue thickness on femoral head fracture rather than obesity, which is defined by increased BMI. Studies in the literature suggest that height increase is positively related to low-energy fractures. Hip fractures are more common in tall people compared to short people (30). BMI also contains the height parameter. The fact that we only used subcutaneous fat tissue thickness as an independent parameter in our study leads to the elimination of the height factor in the studies investigating the relationship between fracture and BMI. In addition to these, the severity, direction, shape of the trauma and the characteristics of the patient other than the subcutaneous fat tissue thickness (age, sex, drug use that may affect BMD, other accompanying clinical conditions such as osteoporosis) were not evaluated in our study and there is a need for studies conducted on a higher number of patients using a higher number of parameters.

The effect of obesity on trauma is multifactorial and varies with age, severity of trauma and localization. Based on our study, one can say that subcutaneous fat accumulation in the abdomen may be a risk factor for complicated hip fractures.

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