



Ischial and pubic osteotomies performed by medial approach during periacetabular osteotomies: an anatomical study

Fuat BİLGİLİ¹, ilke Ali GÜRSES², Ufuk ÖZKAYA¹, Özcan GAYRETLİ²,
Atilla Sancar PARMAKSIZOĞLU¹, Ayşin ÇETİNER KALE²

¹Department of Orthopedics and Traumatology, Taksim Training and Research Hospital, İstanbul, Turkey;

²Department of Anatomy, İstanbul Faculty of Medicine, İstanbul University, İstanbul; Turkey

Objective: The aim of this study was to identify the anatomic landmarks of ischial and pubic osteotomies performed as part of Bernese periacetabular osteotomy, measure the distances of these landmarks to the main neurovascular structures and determine whether these osteotomies can be performed and visualized using a medial approach.

Methods: The study included 20 hemipelvises of 10 formaldehyde-fixed cadavers. A medial surgical approach between the adductor longus and pectineus muscles was used, while protecting the obturator artery and nerve. The superior pubic ramus was subperiosteally exposed to identify the anterior border of the anterior obturator tubercle and the projection point of the highest point of the obturator sulcus on the obturator crest as the two landmarks of pubic bone osteotomy. The line connecting the inferior border of the posterior obturator tubercle and the highest point of the ischial spine on the ischial bone was determined as the osteotomy line. Posterior dissection was carried out to measure the distance from the ischial osteotomy to the pudendal neurovascular structures. All measurements were performed using a digital caliper.

Results: The mean distance from the obturator sulcus to the obturator nerve was 15.3 (range: 8.1 to 30.5) mm. The mean distance from the anterior obturator tubercle to the obturator nerve was 34.3 (range: 27.1 to 49.5) mm and to the obturator artery was 38.5 (range: 29.4 to 51.1) mm. The mean distance from the ischial osteotomy to the pudendal neurovascular structures was 13.6 (range: 11.2 to 17.6) mm.

Conclusion: The 'pubic osteotomy line' connecting the anterior obturator tubercle and obturator crest, and the inferior border of the posterior obturator tubercle (the starting point of the ischial osteotomy line) can be approached and visualized safely using a medial incision in Bernese periacetabular osteotomy.

Key words: Ischial osteotomy; medial approach; periacetabular; pubic osteotomy.

Bernese periacetabular osteotomy is a reconstructive intervention used for treatment of hip dysplasia in adolescents and young adults that comprises a series of ilium, ischium and pubis osteotomies.^[1,2] Bernese periacetabular osteotomy is a technically difficult procedure as the ischium osteotomy is performed blind under fluoroscopy and

pubic osteotomy is performed completely from the medial side of the iliopubic eminence without seeing the surrounding neurovascular structures. Therefore, complications such as major blood loss, neurovascular injury, and intra-articular fracture may occur during the initial part of learning curve.^[3-9] Although injury to the obtura-

Correspondence: Fuat Bilgili, MD. İstanbul Üniversitesi İstanbul Tıp Fakültesi Ortopedi ve Travmatoloji Anabilim Dalı, 34093, Çapa, Fatih, İstanbul, Turkey.

Tel: +90 212 - 414 20 00 / 32493 e-mail: doktorfb2001@yahoo.com

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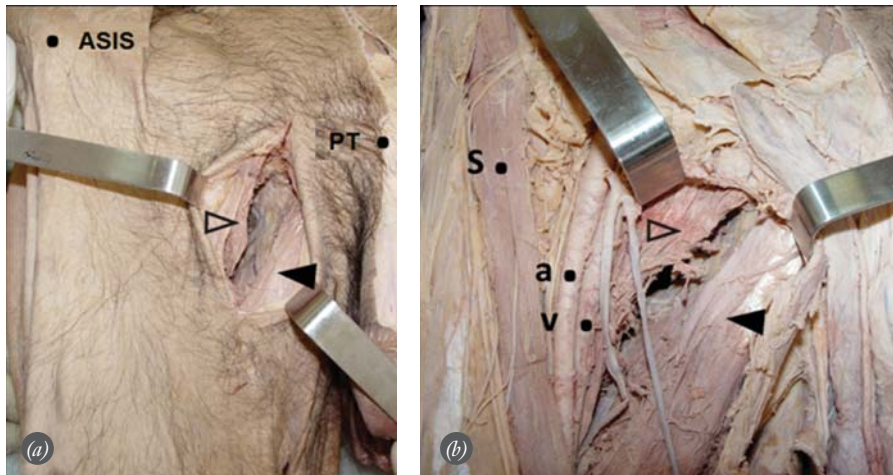


Fig. 1. Anterior appearance of the right anterior femoral region. **(a)** Surgical approach and **(b)** open dissection (a: femoral artery; ASIS: anterior superior iliac spine; black arrow head: the adductor longus muscle; blank arrow head: the pectineus muscle; PT: pubic tubercle; S: sartorius muscle; v: femoral vein). [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

tor artery is rarely reported during pubic osteotomy, the obturator artery and nerve are under risk during this type of osteotomy.^[10,11] Similarly, during ischium osteotomy, the obturator artery in the anterior, pudendal vessel-nerve package and sciatic nerve in the posterior are under risk. Several anatomic studies have been performed to better identify the neurovascular structures in the proximity of the osteotomy line.^[10-14] Using anatomic landmarks for the starting and ending points of osteotomy and the measurement of the distance between these risky neurovascular structures to the osteotomy line would be beneficial for a safe procedure.

The aim of this study was to investigate the anatomic landmarks for the starting and ending points for pubic osteotomies during periacetabular osteotomy, measure the distance of these points to the surrounding neu-

rovascular structures and demonstrate whether the medial approach is suitable for a safe osteotomy.

Materials and methods

Twenty hemipelvises of 10 cadavers (2 female, 8 male) were included in this study. Pelvises were fixed onto the table in a supine position. The skin was opened using a medial incision between the adductor longus and pectineus muscles (Fig. 1). The subdermal layer was dissected and deep fascia exposed. Then, the adductor longus muscle was retracted towards the medial and the pectineus muscle was retracted towards the lateral (Fig. 2), protecting the femoral vessel-nerve package on the anterior aspect of the muscle. The external obturator muscle was elevated from the insertion point to the pubic ramus and the superior pubic ramus was subpe-

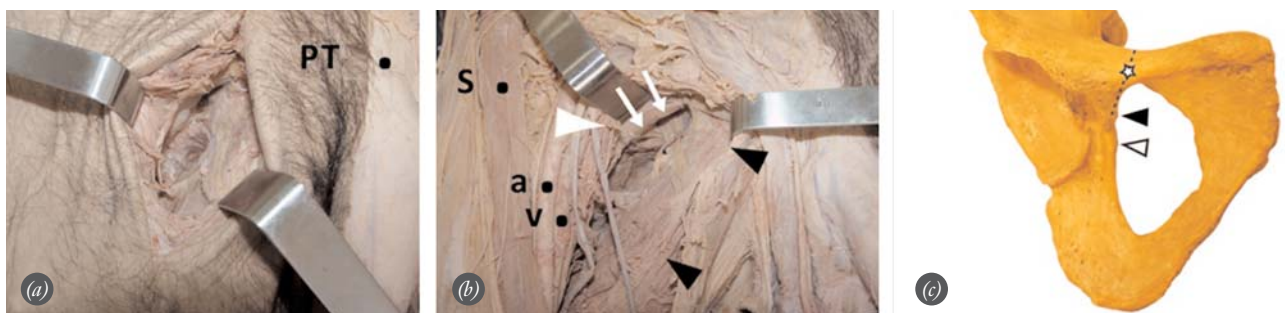


Fig. 2. Anterior appearance of the right anterior femoral region. **(a)** Surgical approach (PT: pubic tubercle), **(b)** open dissection; femoral vessels are protected by elimination of the pectineus muscle (black arrow head: the eliminated adductor longus muscle; a: femoral artery; S: sartorius muscle; v: femoral vein; white arrow head: the eliminated pectineus muscle; white arrows: the superior pubic ramus). **(c)** Landmarks on the hip bone and pubic osteotomy line (asterisk: highest point of the obturator sulcus; black arrow head: the anterior obturator tubercle; blank arrow head: the posterior obturator tubercle; dotted line: pubic osteotomy line). [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

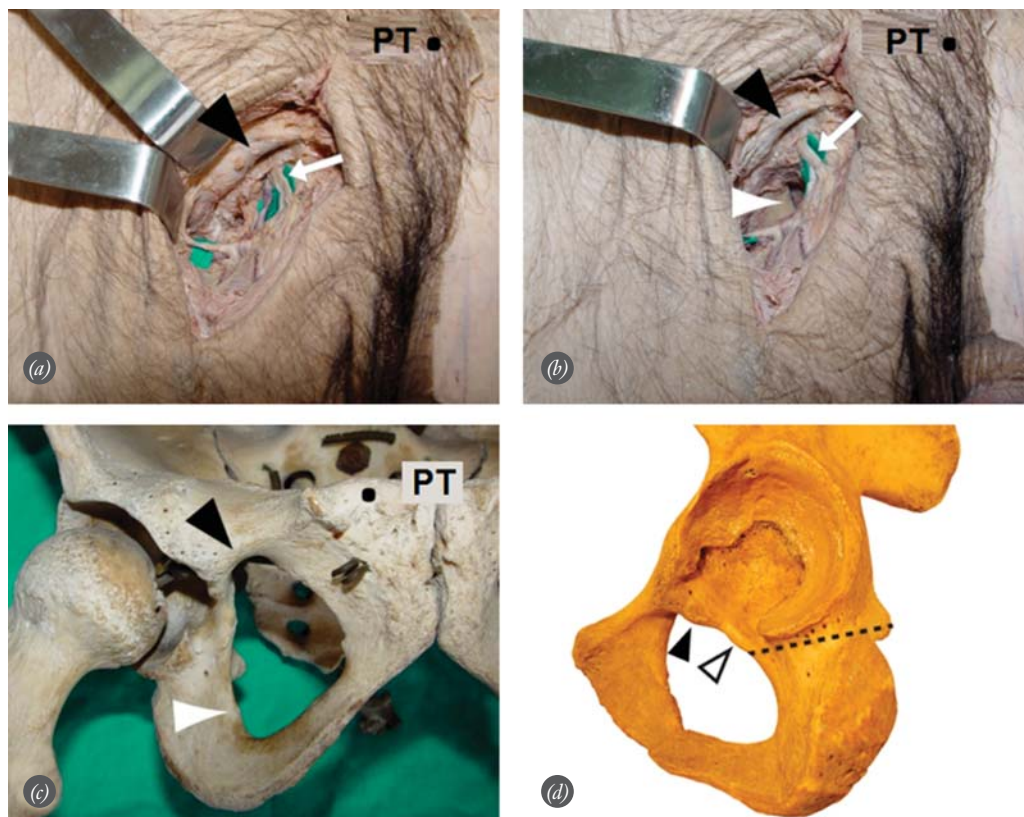


Fig. 3. (a, b) Anterior appearance of the ischium exposed by elimination of the obturator nerve and external obturator muscle during deep dissection of right hip and (c) anterior appearance of the hip bone during surgical approach (black arrow head: superior pubic ramus; PT: pubic tubercle; white arrow: obturator nerve; white arrow head: ischium). (d) Landmarks on the hip bone and ischium osteotomy line (black arrow head: anterior obturator tubercle; blank arrow head: posterior obturator tubercle; dotted line: ischium osteotomy line). [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

riosteally exposed (Fig. 3). Two points, the anterior margin of anterior obturator tubercle and the projection of the highest point of obturator sulcus on the obturator crest, were defined on the superior pubic ramus. The osteotomy line was defined as the line between these two points. The starting point of the osteotomy was marked by an osteotome placed on the cadaver. The point was seen in direct radiographs (Fig. 4). The distances of these two points to the obturator artery, obturator nerve and femoral vein were measured. Dissection was deepened laterally to the ischium arm along the pubis arm. In the region between the ischium and pubis arms, the obturator externus muscle was removed subperiosteally and eliminated towards the anterior. Thus, the obturator artery and vein were protected by removal from the operation field. Just below the acetabulum, the ischium was exposed subperiosteally (Fig. 3). On the body of ischium, the line between the lower border of the posterior obturator tubercle and the highest peak of the ischial spine was defined as the osteotomy line. A posterior dissection was performed in order to define the ending point of the medially planned ischium osteotomy

line and to measure the distance to the nearest vessel-nerve package (Fig. 5). The pudendal vessel-nerve package was the nearest vessel-nerve package to the ischial spine. The deepest points of the greater and lesser sciatic notches were connected with a designed line so that the base of the ischial spine was defined. The distance from the ending point of osteotomy to the pudendal vessel-nerve package was measured (Fig. 5). All measurements were performed using a digital caliper.

Results

From the pubic osteotomy points, the mean distances between the obturator sulcus and the obturator nerve, artery and femoral vein were 15.3 (range: 8.1 to 30.5) mm, 19.5 (range: 10.4 to 32.1) mm, and 27.5 (range: 26.8 to 28.9) mm, respectively. The mean distances between the anterior obturator tubercle and the obturator nerve, artery and femoral vein were 34.3 (range: 27.1 to 49.5) mm, 38.5 (range: 29.4 to 51.1) mm and 8.5 (range: 7.8 to 9.8) mm, respectively. The mean distance of the ischium osteotomy to the pudendal vessel-nerve package was 13.6 (range: 11.2 to 17.6) mm.



Fig. 4. Anterior appearance of (a) the pubis and (b) and ischium osteotomies in radiographs of the right hip.

Discussion

Bernese periacetabular osteotomy (PAO) has become more common in the treatment of hip dysplasia in adolescent and young adult patients.^[3,15] Compared to other osteotomies, Bernese PAO has the advantage of providing better acetabulum correction and better stability. However, disadvantages of the method include blind intervention under fluoroscopy and the risk of complications such as damage to surrounding neurovascular structures and intra-articular fracture.^[4-6] In this study, we demonstrated that a medial approach to the lower border of the posterior obturator tubercle (the osteotomy point on the body of ischium), the projection point of the highest point of the obturator sulcus on the obturator crest and anterior obturator tubercle (the two osteotomy points considered as the osteotomy line) is a safe method.

Various anatomic studies have been conducted to describe the relationship between the blood vessels under risk during periacetabular osteotomy with periacetabular bones.^[11,12,14,16,17] Kambe et al. measured the distances between the anterior inferior iliac spine and external iliac artery and the distance between the base of the superior pubic ramus and obturator artery.^[12] Kinoshita et al.^[10] reported that the obturator artery is located very close to the iliopubic eminence. They showed that the vertical and horizontal distances of the pubic osteotomy line from the medial point of the iliopubic eminence to the obturator artery were 1.8 to 3.3 mm and 0.8 to 2.5 mm, respectively. On the other hand, contrary to this study, they performed pubic osteotomy during periacetabular osteotomy on a horizontal plane (rather than vertical plane) at a 40° oblique angle in order to facilitate medialization of the femur head.

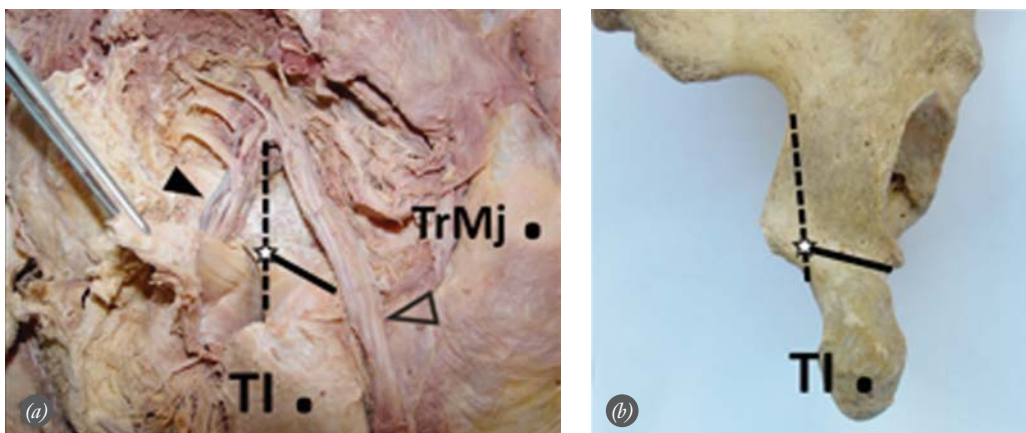


Fig. 5. (a, b) Posterior appearance of the right hip. The relationship of ischium osteotomy line to pudendal vessel-nerve package. For better visualization of the ischial bone, internal obturator muscle was cut from its insertion and removed by a forceps (asterisk: end point of the osteotomy line; black arrow head: pudendal vessel-nerve package; black line: ischium osteotomy line; blank arrow head: sciatic nerve; dotted line: base of ischial spine; TI: tuberosity of the ischium; TrMj: trochanter major). [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Performing pubic osteotomy caudocranially from distal to proximal provides two advantages. First, the corona mortis, seen in only 30% of the general population,^[18] is kept in a distance. Second, as the osteotomy line is longer, reunion is expected to be easier. Reported pubic non-union rate is 9% in the literature.^[3]

The obturator artery is also under risk during ischium osteotomy, which may be safely conducted using an anterior approach.^[11] One of the important issues in ischium osteotomy performed using an anterior approach is the separation of the posterolateral part by a controlled fracture under fluoroscopy after correct positioning of the osteotomy terminal and cutting the medial part of the bone. Despite fluoroscopy use, this may be difficult.^[14] Therefore, we first defined the posterior obturator tubercle as the osteotomy point which may be palpated on the body of ischium. Then, we demonstrated that through a medial approach, a safe access to this point is possible. Again, we demonstrated that the pudendal vessel-nerve package at the posterior is in an adequately safe distance to the osteotomy ending point.

As the periacetabular osteotomy is a difficult operation, various modified interventions and approaches have been described to reduce complications. Generally, ilioinguinal, modified Smith-Peterson and direct anterior osteotomies extend to the intra-articular region or may lead to posterior column fracture. Damage to blood vessels is also commonly seen. Therefore, a combined anteroposterior or endoscopy-assisted interventions which enables a clear vision of the osteotomy field have been described.^[2,12,14,16,19,20] In parallel, we identified palpable anatomic markers to reduce the risk of intra-articular fracture. We verified that these points are in safe distance to the surrounding neurovascular structures and that a medial approach provides a safe access to these points.

As our study was performed on cadavers fixed by formaldehyde, positioning and elimination of anatomic parts were limited. In addition, we were unable to evaluate the risk of bleeding and of intraoperative problems due to bleeding. However, cadaveric studies are very important for feasibility assessments.

In conclusion, in cadavers, pubic and ischium osteotomies during periacetabular osteotomy can be safely conducted using a medial approach. To better show the clinical advantages of the medial approach, additional studies should be done on patients.

Conflicts of Interest: No conflicts declared.

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