Modified Medial Stoppa Approach For Acetabular Fractures: An Anatomic Study

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Background: The modified medial Stoppa approach is an alternative and new surgical approach to access to the internal pelvis and medial wall of the acetabulum. There is little information about the clinical anatomic specifications of exposure in the literature. In this study, the pertinent surgical anatomy that involved the modified medial Stoppa approach was further defined and the anatomic positions and variations of the structures seen in the surgical site were analyzed.

Methods: We dissected five formalized cadavers to present structures at risk in a standard modified medial Stoppa approach. The internal iliac artery and branches were colored with latex injection in formalized cadavers. Morphometrical measurements of the neurovascular structures adjacent to quadrilateral surface and their anatomic variations were noted.

Results: It was detected that the obturator vessels and nerve and the iliolumbar vessels were primarily the structures at risk. Obturator vessels and nerve were the most important structures to pay attention because of their direct contact to quadrilateral surface. There was communication (corona mortis) between obturator and inferior epigastric veins in 4 (40%) of 10 hemipelvises.

Conclusions: Before clinical applications, performing cadaver dissection is important to minimize intraoperative complications. This study was the first anatomic study in the literature that reveals the structures that are at risk during surgical treatment of acetabular fractures, which was treated with the modified medial Stoppa approach.

Key Words: Modified medial Stoppa approach, Cadaver, Anatomy.

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Displaced acetabular fractures are best treated by open reduction and internal fixation like any other intra-articular fractures. Many studies have indicated that late traumatic osteoarthrosis is lowered by a successful operative reduction.[1–5] The main obstacle to reduction in a severely displaced acetabular fracture is easy access to the fracture site and good visualization of the surrounding structures. Both extensile and nonextensile exposures can be used for surgical approach, the Kocher-Langenbeck, ilioinguinal, and extended iliofemoral being the most common. Although extensile exposures provide clear visualization, they have resulted in higher complication rates and more morbidity than nonextensile exposures. When choosing a surgical approach, the least invasive approach that allows effective reduction and fixation of the acetabulum fractures should be preferred.

Originally used for hernia repair and surgery, the recently modified medial Stoppa approach has also been used for the treatment of pelvic and acetabular fractures as a nonextensile exposure.[6–9] This approach provides access to the medial wall of the acetabulum, quadrilateral surface, and sacroiliac joint and may be an alternative to the commonly used approaches. The modified medial Stoppa approach was first described by Hirvensalo et al.[10] and later by Cole and Bolhofner[11] as a new technique in orthopedic surgery for fractures of the anterior column or wall, transverse fractures, T-type fractures, both column fractures and fractures of the anterior wall, or the column associated with posterior hemitransverse fractures.[6,7,10–12]

The number of clinical studies investigating fractures treated with this approach is limited, and also there is little information about the long-term results. Moreover, there are no relevant clinical anatomic studies in the literature. This study aimed to investigate the anatomic structures in the surgical field, the positions, and variations of these structures and to further define the pertinent surgical anatomy involved in the modified medial Stoppa approach. The hypotheses questioned in this study were as follows:

1. Which anatomic structures frequently constrain the application of this approach and what are their precise locations?
2. Do neurovascular structures in the region have variations that increase the difficulty of surgical dissection and thereby surgical operation?
3. What is the applicability of this approach in orthopedic surgery?

MATERIALS AND METHODS

This study conformed to the Helsinki Declaration. Five formalized cadavers (3 men and 2 women) were dissected to analyze their anatomic structures in the intrapelvic area and the localization and variations of these structures. The mod-

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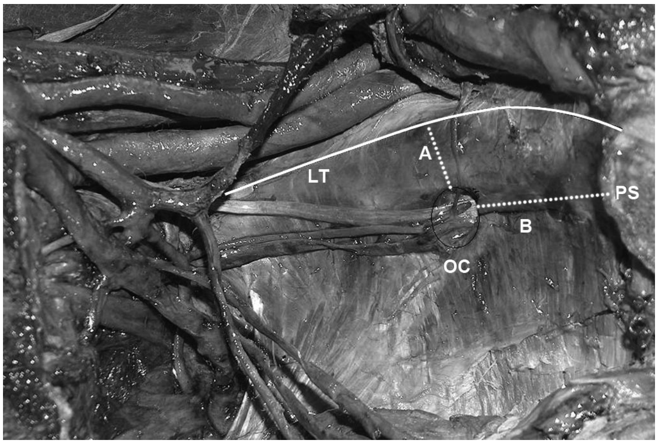

Figure 1. The relation of the obturator canal with the bone structures. (*A*) The distance between linea terminalis (iliopectineal line) and obturator canal. (*B*) The distance between pubic symphysis and obturator canal. LT, linea terminalis; OC, obturator canal; and PS, pubic symphysis.

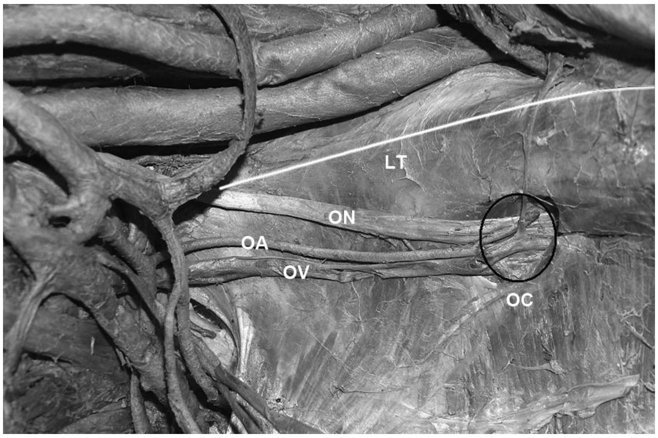

Figure 2. The normal course of the obturator artery, vein, and nerve. LT, linea terminalis (iliopectineal line); ON, obturator nerve; OA, obturator artery; OV, obturator vein; and OC, obturator canal.

ified medial Stoppa approach defined by Cole and Bolhofner[11] was applied. An incision over the external ring was made horizontally from 2 cm proximal to the pubic symphysis. The rectus abdominis muscles were separated vertically and liberated by cutting from the pubic adhesions. In the suprapubic region, the bladder was observed in the retroperitoneal area. Dissection continued from the retroperitoneum sighting and retracting the external iliac artery and below the femoral nerve. The iliopectineal fascia and periosteum were released by sharp dissection to access the internal part of the pelvis. By suspending the iliopsoas muscle, the iliopectineal line was revealed. This approach provided access to the internal part of the pelvis from the pubic symphysis to the sacroiliac joint. The location of the quadrilateral surface was determined by locating the sciatic notch and obturator foramen. The neurovascular structures related to the quadrilateral surface and iliopectineal line were detected (Fig. 1).

First, to observe the common iliac artery and its branches properly, a detailed dissection was performed, and latex was injected into the vessels. The common iliac artery was cut 1 cm to 2 cm distal from the bifurcation of the aorta, liberating the end of the vessel into which a scalp vein set was inserted and the needle fixed by suture ligation over the vessel. Before the latex injection, the vessel was washed with physiologic serum several times to decrease intravascular congestion and coagulum. To increase the fluidity of the latex, a viscous solution commonly used in cadaver studies, which was diluted with 25% distilled water, and a homogeneous colored solution was prepared using red China ink. The prepared latex solution was injected slowly into the vessel with the scalp vein set, and when pressure occurred, the injection was discontinued for some time to allow the distribution of latex within the vessel. When the injection was completed, the scalp vein set was removed slowly, and the common iliac artery was ligated immediately. To allow fixation of the latex, the material was kept at room temperature for 24 hours after which all the hemipelvises were dissected, and morphometric measurements were performed. All cadavers were placed in the supine position, and gross and microdissection techniques were used. The neurovascular structures related to the quadrilateral surface and iliopectineal line were observed. The dimensions in their original anatomic structures were measured using an electronic caliper (Best 150 × 0.01 mm) and flexible ruler. In addition, microdissection tools and the microsurgery microscope were used. To minimize the risk of error during these steps, all steps were performed by the same investigator (B.K.K.).

RESULTS

The course of the obturator vessels and nerve was examined in detail because of their direct relationship with the quadrilateral surface. It was observed that the obturator artery originating from internal iliac artery, together with the obturator vein to which it was superior, entered the canal almost parallel to the iliopectineal line (Fig. 2).

In both hemipelvises of one cadaver, it was observed that the obturator artery originating from the inferior epigastric artery crossed the pubic ramus and then directly entered the obturator canal (Fig. 3). In two hemipelvises, it was observed that a second obturator vein originating from the external iliac vein directly entered the obturator canal by crossing the iliopectineal line (Fig. 4). Measurements concerning the sources of the obturator artery and vein are presented in Table 1 (Fig. 5).

The obturator nerve originating from the lumbar plexus directs to the obturator canal by crossing the iliopectineal line close to sacroiliac joint. The mean distance of the point where the obturator nerve crossed the iliopectineal line to the sacroiliac joint was 17.7 mm (11.1–30.0 mm) on the right and 22.4 mm (10.1–40.0 mm) on the left. The mean distance from the point where the obturator

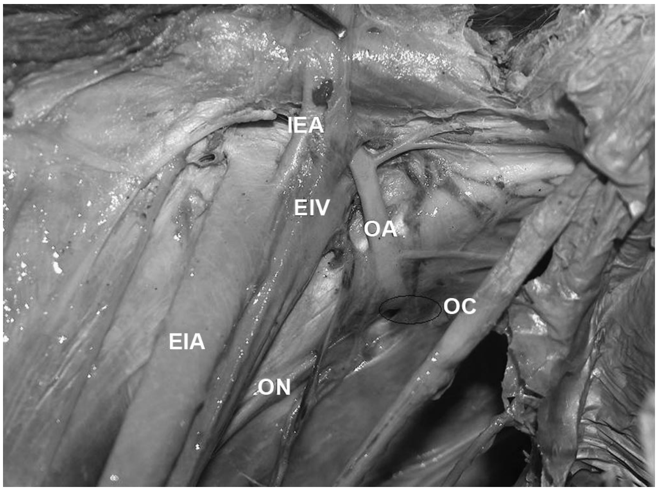

Figure 3. The variation of the obturator artery. IEA, inferior epigastric artery; EIA, external iliac artery; EIV, external iliac vein; OA, obturator artery; ON, obturator nerve; and OC, obturator canal.

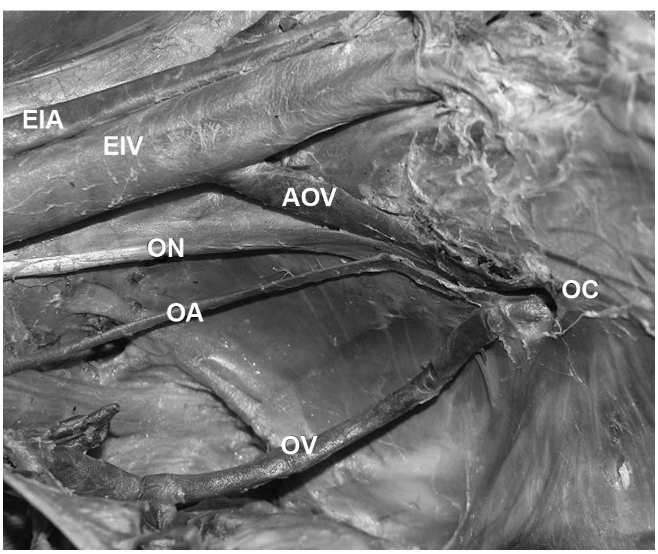

Figure 4. The accessory obturator vein. EIA, external iliac artery; EIV, external iliac vein; OA, obturator artery; OV, obturator vein; ON, obturator nerve; OC, obturator canal; and AOV, accessory obturator vein.

nerve entered the obturator canal to the iliopectineal line was 18.8 mm (Table 2).

In 4 (40%) of 10 hemipelvises dissected, there was communication (corona mortis) between the obturator and inferior epigastric vessels. Half of these communications were venous only, whereas there were both arterial and venous communications in the other half (Fig. 6).

The iliolumbar artery originates from the posterior division of the internal iliac artery. It ascends from the posterior of the obturator nerve and then lies along the medial surface of the psoas muscle and crosses the iliopectineal line (Fig. 7). It is often separated into two branches, the lumbar

TABLE 1. Measurements Regarding Obturator Artery and Vein

	Obturator Artery		Obturator Vein	
	Right	Left	Right	Left
Mean length of vessels (mm)	52.9	58.1	49.3	49.3
The distance from the obturator canal entrance to linea terminalis (mm)	22.8	22.9	20.1	22.9
The distance from the root to linea terminalis (mm)	14.6	25.9	24.7	34.0
The distance from the midpoint to linea terminalis (mm)	16.0	21.3	20.9	29.2
The distance from the midpoint to linea terminalis by retraction (mm)	29.1	28.5	33.7	38.5

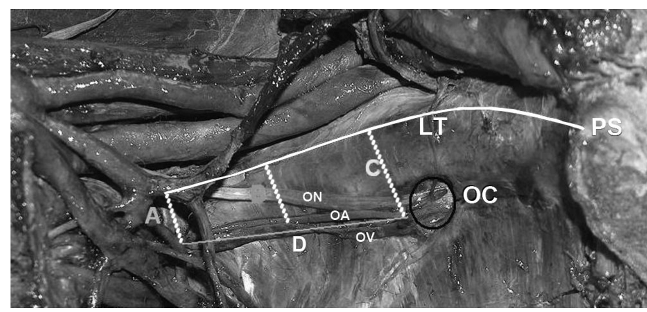

Figure 5. The measurements concerning obturator artery. (*A*) In the place where the root reveals the distance to linea terminalis (iliopectineal line). (*B*) The distance from the middle point to linea terminalis. (*C*) In the obturator canal entrance, the distance to linea terminalis. (*D*) Length of the obturator artery. LT, linea terminalis; PS, pubic symphysis; OA, obturator artery; OV, obturator vein; ON, obturator nerve; and OC, obturator canal.

TABLE 2. Measurements Regarding Obturator Nerve

	Obturator Nerve	
	Right	Left
The distance to linea terminalis at the obturator canal entrance (mm)	19.0	18.7
The distance from the intersection point of linea terminalis to sacroiliac joint (mm)	17.7	22.4
Maximum distance to linea terminalis by retraction (at the intersection point)	13.5	12.7

and the iliac, supplying the psoas muscle and the iliacus muscle, respectively. There was no iliolumbar artery in one (10%) and no iliolumbar veins in four (40%) of the hemipelvises dissected. Although five (50%) of the iliolumbar arteries separated into two branches, it was observed that four (40%) separated into three branches. Although no branching of the iliolumbar vein was observed in four (40%) of the pelvises, two (20%) separated into two branches. The distances of the points where the iliolumbar artery and vein

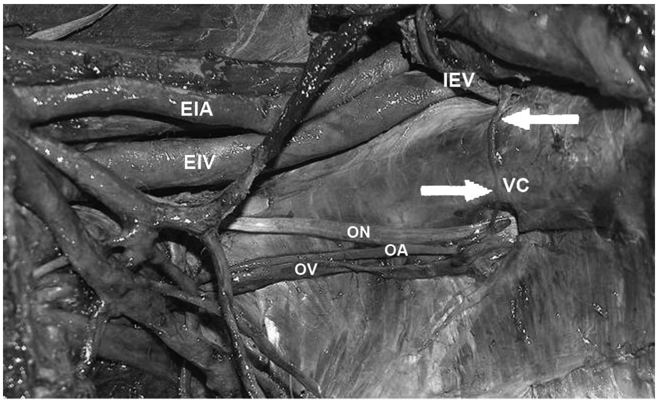

Figure 6. The venous communication between inferior epigastric vein and obturator vein "corona mortis." EIA, external iliac artery; EIV, external iliac vein; OA, obturator artery; OV, obturator vein; ON, obturator nerve; VC, venous communication (red arrows); and IEV, inferior epigastric vein.

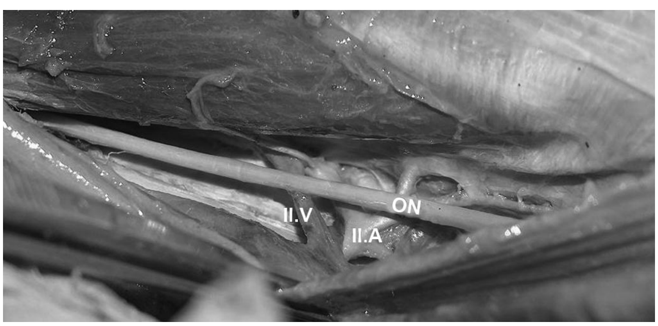

Figure 7. Iliolumbar vessels and obturator nerve. Il.V, iliolumbar vein; Il.A, iliolumbar artery; and ON, obturator nerve.

TABLE 3. The Distance From the Point Where Iliolumbar Artery and Vein Intersected the Linea Terminalis to Sacroiliac Joint

	Iliolumbar Artery			Iliolumbar Vein	
	First Branch	Second Branch	Third Branch	First Branch	Second Branch
The distance from the intersection point of linea terminalis to sacroiliac joint (mm)	0.1	6.4	21	11.4	15.3

branches intersected the iliopectineal line to the sacroiliac joint were also measured (Table 3).

DISCUSSION

Although intrapelvic approaches for the treatment of acetabular fractures have the advantages of providing a wide surgical field, easy postoperative rehabilitation, and a low rate of heterotopic ossification, the learning curve is quite sharp because of many critical anatomic structures in the surgical field.[2,11,13] The ilioinguinal approach, which is commonly used within intrapelvic approaches, is performed by surgeons having a certain level of experience because it necessitates dissection of neurovascular structures and the regions surrounding these structures. To facilitate this surgical technique and to provide easy access to the medial wall of the acetabulum, the approach has been modified by several researchers.[1,14]

Significant complications such as deep infection, limitations of the movements of the hip joint, heterotopic ossification, nonunion of the trochanter major osteotomies, and late avascular necrosis are commonly addressed with extensile exposures. The modified medial Stoppa approach provides reduction and fixation opportunity in fractures with medial displacement and has a low complication rate. Nevertheless, the complex anatomy of the surgical field requires careful study. Researchers who have used the modified medial Stoppa approach report that in surgical treatment of acetabular fractures related to the quadrilateral surface, adequate reduction and fixation can be provided by the approach together with infrapectineal plating, especially in cases with medial displacement of the femoral head.[6,7,10,11]

In several studies investigating acetabular fractures, the anatomic structures in the surgical region have been described; however, there are very few detailed anatomic studies concerning these structures. Most clinical anatomic studies are mainly concerned with bone structure[15,16]; but in this study, we aimed to further define the pertinent surgical anatomy involved in the modified medial Stoppa approach and to obtain a detailed anatomic measurement of vascular and neural structures related to the bony surfaces. Because the obturator vessels and nerve are in close proximity to the quadrilateral surface and are the anatomic structures that must be considered in the modified medial Stoppa approach, these structures have been examined comprehensively in this study. A clinically important variation of the obturator artery was observed in two (20%) of the hemipelvises. In these particular cadavers, the obturator artery originating from the inferior epigastric artery crossed the pubic ramus and then directly entered the obturator canal. Gilroy et al.[17] investigated 105 hemipelvises and reported that obturator vessels had variations in 82%.

In 40% of the dissected hemipelvises in this study, communication existed between the obturator and inferior epigastric vessels. These communications were first defined by Haller in 1745.[17] The variations or vascular anastomoses were named "corona mortis." Berberoglu et al.[18] examined the findings of both cadaver dissection and laparoscopy and reported venous communication as 96%. Okcu et al.[19] reported a 61% incidence of corona mortis in 150 hemipelvises. Drewes et al.[20] reported this ratio as 66.7%. In the studies conducted, communications were observed to be commonly venous. Darmanis et al.[21] found vascular anastomosis in 83% of cadaveric specimens. They observed that 60% of these anastomotic vessels had a large diameter (3 mm). However, they reported only five cases with abnormal vascular communication in a total number of 492 cases in a clinical setting.[21] The extension of plates used during the treatment of acetabulum fractures with intrapelvic approaches to the pubic ramus allows the careful examination of these common vascular structures with a high risk of bleeding in if injured by orthopedists.

The obturator nerve is an important neural structure that should be considered during intrapelvic approaches. Although the incidence of the accessory obturator nerve is reported between 8% and 29%, in this study we found no variations concerning accessory obturator nerve and its course. Because the obturator nerve directs to the obturator canal by crossing the iliopectineal line, the risk of injury increases during plate applications. In this study, this intersection was ~20.0 mm distant from the sacroiliac joint. At that point, the nerve was distracted only 13.1 mm from the iliopectineal line by retraction. Locher et al.[22] measured the distance between the obturator nerve and the anterior border of the superior ramus of the pubis on the sagittal plane. This measurement provides information on the depth of the obturator nerve after the bone has been contacted by the needle when performing an obturator nerve block. The distance was 2.0 cm (min 1.5 cm, max 2.8 cm). In this study, the distances to the iliopectineal line at the obturator canal entrance for the right and left obturator nerve were observed as 19.0 mm and 18.7 mm, respectively. In clinical situations, this distance may be shorter because soft tissues are tighter in vitro and the nerve may be injured by rough retraction. In the obturator canal entrance, the obturator nerve was observed to be the closest structure to the iliopectineal line (Fig. 2). Although the obturator artery and vein could be distracted from the iliopectineal line by retraction at their midpoints, the distance to the canal entrance did not change. This necessitates careful application of plates, at the level of the obturator canal.

Because of their close proximity to the iliopectineal line, the iliolumbar artery and vein are clinically important anatomic structures. Jasani and Jaffray[23] emphasized that in lumbar spine surgery the iliolumbar vein should be dissected carefully and ligated in anterior approaches. There was no iliolumbar artery in 10% of the hemipelvises dissected in this study and there was no vein in 40%. Because of the close proximity of the iliolumbar vessels to the sacroiliac joint, there may be serious bleeding in cases of extension of the plates to the sacroiliac joint unless they are carefully dissected and ligated. The obturator nerve, iliolumbar artery, and vein cross each other and the iliopectineal line is in close proximity to the sacroiliac joint (Fig. 7). Thus, they are important anatomic structures to consider not only in fractures of the acetabulum but also in separations of the sacroiliac joints.

This study confirmed the feasibility and applicability of the exposure of the acetabulum regarding anatomic relationships. The strength of the study was in performing the latex injection into the arterial structures, which provided precise evaluation of these structures. The main limitations of this study were the small number of cadavers, the use of formalized cadavers, and the measurements were done on intact acetabula. However, to the best of the authors' knowledge, this is the first anatomic study of its kind and it will encourage us to use this technique on patients.

This study showed that obturator vessels and nerve are the most important structures requiring attention because of their direct relation with quadrilateral surface. It was also observed that complete distraction of these structures from the surgical site by retraction is not entirely possible. Because the modified medial Stoppa approach necessitates studying a surgical field with important anatomic structures on the internal surface of pelvis, performing cadaver dissection before clinical applications is most valuable to minimize intraoperative complications.

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