Is the obturator artery safe when performing ischial osteotomy during periacetabular osteotomy?

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Abstract The purposes of this study were (1) to evaluate the actual distance between the obturator artery and the ischial osteotomy site when performing periacetabular osteotomy via an anterior approach and (2) to determine a safe method to avoid injuring the obturator artery during this procedure. Twenty-nine hemipelves from cadavers were used in this study. The mean distance between the obturator artery and the ischial osteotomy site was 35.6 ± 7.5 mm and always exceeded 20 mm. Therefore, the procedure can be performed safely when a chisel blade of 20 mm or shorter is used.

Introduction

Hip dysplasia is characterised by insufficient acetabular coverage of the femoral head and is a common cause of secondary hip arthrosis. Many types of pelvic osteotomy have been designed to increase the acetabular coverage of the femoral head [3, 5, 8, 11, 13, 18]. Periacetabular osteotomy is one such and is reported to be an effective treatment for hip dysplasia [7–13, 15]. In this approach, an ischial osteotomy via the anterior approach is performed using a chisel observed with an image intensifier without direct visibility. The chisel blade appears to be in the obturator foramen when viewed through the image intensifier. Part of the chisel blade is advanced from the

obturator foramen into the pelvic cavity (Fig. 1). At this point there is a risk of injury to the obturator artery, as it passes through this foramen close to the path of the chisel blade. Although uncommon, injuries to branches of the internal iliac artery during periacetabular osteotomy (including the obturator artery) are reported to be serious causes of intraoperative bleeding [2, 14]. The anatomical relationship between the obturator artery and the ischial osteotomy site during periacetabular osteotomy has not been elucidated in detail.

The purposes of this study were (1) to evaluate the actual distance between the obturator artery and the ischial osteotomy site when performing periacetabular osteotomy via an anterior approach and (2) to determine a safe method to avoid injuring the obturator artery during this procedure.

Materials and methods

Twenty-nine hemipelves (19 from 15 male cadavers and ten from seven female cadavers) were used in this study. The mean age at the time of death was 80.2 ± 10.5 years. The mean height of the donors when alive was 161.1 ± 5.1 cm for men and 146.8 ± 9.0 cm for women. None of the cadavers had any obvious bony deformities. Each hemipelvis was resected through the sagittal plane; the soft tissues including the muscles peripheral to the hip joint were stripped, and the femur and pelvic organs were removed. The obturator artery was identified.

Three anatomical data points were defined as follows (Fig. 2): (1) point P was the proximal origin of the rectus femoris on the anteroinferior iliac spine, (2) point D was the distal origin of the rectus femoris on the anteroinferior iliac spine and (3) point E was the entry point of the obturator artery into the obturator foramen. The ischial osteotomy site

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Fig. 1 The position of the chisel during ischial osteotomy. **a** Radiograph during ischial osteotomy. The blade of the chisel appears to be in the obturator foramen through an image intensifier. **b** Photograph of the medial aspect of a right hemipelvis during an

ischial osteotomy. Part of the chisel has been advanced from the obturator foramen into the pelvic cavity. A chisel with a 20-mm long blade is used in our hospital during this procedure.

was defined by drawing a line in each hemipelvis according to the procedure for ischial osteotomy described by Ganz et al. [8] (Fig. 2). Vertical lines were drawn from the data points P and D to the arcuate line and the corresponding intersections were defined as points P' and D', respectively. Two other vertical lines were drawn from points P' and D' to the ischial osteotomy site and their intersections were defined as points P'' and D'', respectively. Another vertical line was drawn from point E to the ischial osteotomy site and its intersection was defined as point E'. The shortest distance between the obturator artery and point P'' was

measured and defined as item 1. The shortest distance between the obturator artery and point D'' was measured and defined as item 2. The shortest distance between the obturator artery and point E' was measured and defined as item 3. These measurements were analysed with regard to differences between sexes. A digital caliper (Mitutoyo, Tokyo, Japan) with an accuracy of ± 0.02 mm was used for all of the measurements.

Statistical analyses were carried out using the non-parametric Mann-Whitney U test and significance was assumed at $P < 0.05$.

Fig. 2 Distances between the obturator artery and the ischial osteotomy site. **a** Photograph of the medial aspect of a right hemipelvis. **b** Illustration of the data points and distances measured. The following measurements were taken: item 1, the shortest distance between the obturator artery and point P''; item 2, the shortest distance between the obturator artery and point D''; item 3, the shortest distance between the obturator artery and point E'. *AIIS* anteroinferior iliac spine, *AL* arcuate line, *point P* proximal origin of the rectus femoris on the AIIS, *point D* distal origin of the rectus femoris on the AIIS, *point E* entry

point of the obturator artery into the obturator foramen, *point P'* intersection of a vertical line (dashed) between point P and the AL, *point D'* intersection of a vertical line (dashed) between point D and the AL, *point E'* intersection of a vertical line (dashed) between point E and the ischial osteotomy site, *point P''* intersection of a vertical line (dashed) between point P' and the ischial osteotomy site, *point D''* intersection of a vertical line (dashed) between point D' and the ischial osteotomy site. The letters and lines in red, blue and green indicate factors related to points P, D and E, respectively.

Results

The mean distances between the obturator artery and the ischial osteotomy site in Fig. 2 were as follows: item 1, 33.4 ± 6.7 mm at point P''; item 2, 31.1 ± 6.3 mm at point D''; and item 3, 41.9 ± 5.4 mm at point E'. Overall, the mean distance between the obturator artery and the ischial osteotomy site was 35.6 ± 7.5 mm. The measurements for each sex are summarised in Table 1. All items were significantly longer in male than in female specimens ($P=0.0073$ for item 1, $P=0.026$ for item 2 and $P=0.027$ for item 3).

Discussion

Periacetabular osteotomy for early or moderate hip osteoarthritis caused by developmental dysplasia provides favourable clinical results in young patients [7–13, 15]. However, it is impossible to expose the ischial osteotomy site by direct vision when using the anterior approach. Therefore, ischial osteotomy is performed with the surgeon using an image intensifier. During this visualisation the tip of the chisel blade appears to be in the obturator foramen, where the obturator artery runs. Therefore, injury to the obturator artery remains a major concern for this procedure [2, 14].

Anatomy textbooks show where the obturator artery is located [1, 4, 16, 17]. However, there is almost no useful information for surgeons because the pelvic organs are

illustrated with the obturator artery intact and indicators of distance are not usually shown. It is difficult to understand the anatomical relationship and the distance between the obturator artery and the ischial osteotomy site. We considered that a cadaveric study would be necessary to clarify anatomical concerns.

Although Ganz et al. [8] reported that there is little risk of injury to neurovascular structures at the ischial osteotomy site during periacetabular osteotomy, they did not provide anatomical data. de Kleuver et al. [6] reported that periacetabular osteotomy is associated with a higher risk of damage to neurovascular structures than is triple osteotomy, because of the reduced visibility for the surgeon and the additional difficulty in accurate orientation. Direct haemostasis is almost impossible and an endovascular embolism is inevitable if the obturator artery is injured during surgery [2, 14]. To avoid injury to the obturator artery, it would be useful to obtain information on how far this artery is located from the ischial osteotomy site.

The distances from the obturator artery to the ischial osteotomy site differed significantly between sexes in the cadaveric hemipelves we studied. This finding indicates that ischial osteotomy is potentially more dangerous for female than for male patients in terms of damage to this artery. This is important because most of the patients affected by acetabular dysplasia are women. However, the mean distances between the obturator artery and the position of the chisel blade were greater than 20 mm in

Table 1 Mean distances between the obturator artery and the ischial osteotomy site in each sex

Number of Item	Average Distance in Each Sex ± SD (mm)	
1	Female: 29.7 ± 5.6	**
	Male: 36.1 ± 5.0	
2	Female: 27.2 ± 4.2	*
	Male: 33.1 ± 6.4	
3	Female: 38.7 ± 4.3	*
	Male: 43.6 ± 5.1	

** $p < 0.01$; * $p < 0.05$

The distances between the obturator artery and the ischial osteotomy site were significantly greater in male than in female. Item 1, the shortest distance between the obturator artery and Point P''; Item 2, the shortest distance between the obturator artery and Point D''; Item 3, the shortest distance between the obturator artery and Point E'.

both sexes. When a chisel with a blade of 20 mm or shorter is used, ischial osteotomy during periacetabular osteotomy can be performed safely via the anterior approach because the obturator artery is located sufficiently far from the ischial osteotomy site, regardless of the sex of the patient.

The minimum measured value of distance between the obturator artery and the ischial osteotomy site was 21.9 mm in this study. We normally use a chisel with a blade of 20 mm during this procedure (Fig. 1b). Although the difference between the minimum measured value of distance and the blade length is only 1.9 mm, surgery can be performed safely because the tip of the blade is directed to a posteriorly proximal position, not to a vertically proximal position. In other words, the chisel cannot deviate vertically from the ischial osteotomy site and reach the obturator artery.

There were a couple of limitations to our study. First, the Asian cadavers studied were of small stature with a mean height of 161.1 cm in men and 146.8 cm in women. Second, there were almost twice as many hemipelves from male cadavers than from female cadavers. However, we believe that the results of this study could be useful when performing periacetabular osteotomy on hips in patients of larger stature.

In conclusion, we investigated the anatomical distance between the obturator artery and the ischial osteotomy site during periacetabular osteotomy. This procedure can be performed safely via the anterior approach if a chisel with a blade of 20 mm or shorter is used.

Conflict of interest The authors declare that they have no conflict of interest.

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