Anatomic study for pubic medullary screw insertion

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INTRODUCTION

In North America and Europe, percutaneous, fluoroscopy-assisted antegrade or retrograde medullary pubic ramus screws have been used for fixation of an unstable pelvic ring and acetabular injuries,1–8 particularly for pubic fractures of the iliopectineal eminence. This technique avoids
open reduction and internal fixation using a 10-hole plate through a wide exposure such as the ilioinguinal approach, and provides similar pubic motion control.\textsuperscript{5,8,9} Pubic screw fixation is minimally invasive,\textsuperscript{1,3,4} but is potentially disastrous because of its proximity to the bladder, iliac artery, and iliac vein.\textsuperscript{5,8} Care must be taken to avoid screw penetration in case of anatomic variations (related to curvature of the superior pubic ramus, the diameter of the medullary canal, and the direction of the pubic ramus).\textsuperscript{4} We therefore studied the anatomy of the pubic ramus and adjacent structures in 160 Japanese to establish a safer pubic screw fixation technique.

**MATERIALS AND METHODS**

Between January 2005 and August 2006, 80 male and 80 female Japanese aged 16 to 89 (mean, 50) years (10 persons in each decade of age) underwent 3-dimensional computed tomographic scanning of their pelvises in a supine position. The hip and knee joint were extended, with acquisition parameters of 350 mA, 120 kVp, 0.6 seconds, 1.35 pitch, 7.5 mm slice thickness, 2.5 mm reconstruction thickness, and 0.5 mm overlap.

Patients with pelvic and acetabular fracture, apparent pelvic deformity or asymmetry, developmental dysplasia (Sharp angle >45\(^\circ\)), or advanced osteoarthritis of the hip were excluded, as were those aged <16 years (most of whom had open triradiate cartilages).

An axis for screw insertion was drawn starting at the centre of the pubic tubercle, through the mid-portion of the pubic ramus and superior bone cephalad to the acetabulum, and then exiting the lateral ilium (Fig. 1a). Reconstructed cross-sectional images perpendicular to this axis were obtained at 1-mm intervals. Circles in contact with at least 2 edges of the bone were drawn along the axis, and the canal diameters measured. The canal was narrower in the area superior to the acetabulum centre or slightly posterior to the iliopectineal eminence, the base or iliopectineal area of the pubic ramus, and the parasymphyseal area (Fig. 1b). The smallest canal diameter in the 3 areas determined the screw diameter. The distances from the lateral ilium to the smallest canal diameters in each of the 3 areas were recorded. The length and angle of this axis and exiting area on the lateral ilium were measured, which was a landmark for antegrade screw insertion (intersection point of perpendicular lines from the tip of the anterior inferior iliac spine and from the superior edge of the acetabulum).

The distances from the posterior border of pubis...
to the bladder at the parasymphyseal area, and those from the superior border of the pubis to the iliac artery and vein around the medial margin of the acetabulum were measured on reconstructed cross-sectional images perpendicular to the axis (Fig. 3).

Correlations between the canal diameters in the 3 areas and body features (such as age, height, and weight) were analysed using the Pearson correlation coefficient test. A p value of <0.05 was considered significant.

RESULTS

In men and women respectively, the mean heights were 166 (range, 150–190) and 154 (range, 137–166) cm, the mean weights were 60 (range, 42–110) and 52 (range, 32–77) kg, the mean axis lengths between the pubic tubercle and lateral ilium were 124.6 (range, 103.7–141.7) and 123.8 (range, 110.6–143.4) mm, and the mean exiting areas on the lateral ilium were the intersection point between 37.7 and 28.5 mm from the tip of the anterior inferior iliac spine and 24.3 and 17.5 mm from the superior edge of the acetabulum.

In men, all canal diameters were >10 mm; the largest was at the base and smallest at the parasymphyseal area. In women, the minimum canal diameter was 7.8 mm at the acetabulum, 8.6 mm at the base, and 7.3 mm at the parasymphyseal area (Table 1). In men, the mean distances from the lateral ilium to the smallest canal diameters at the acetabulum, base, and parasymphyseal area were 41.2, 54.8, and 120.6 mm, respectively. In women, the corresponding figures were 40.8, 53.6, and 118.8 mm.

In both men and women, the minimum distances from the pubis to the bladder/iliac artery/iliac vein were 0 and 0 mm/4.9 and 4.6 mm/0.8 and 0.2 mm (Table 1).

RESULTS

In both men and women, canal diameters at the

Table 1

<table>
<thead>
<tr>
<th>Pubic anatomy</th>
<th>Men (n=80)</th>
<th>Women (n=80)</th>
</tr>
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<tbody>
<tr>
<td>Mean (range)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetabulum</td>
<td>14.2 (11.1–17.5)</td>
<td>11.6 (7.8–14.0)</td>
</tr>
<tr>
<td>Base</td>
<td>14.8 (10.8–17.9)</td>
<td>13.3 (8.6–16.8)</td>
</tr>
<tr>
<td>Parasymphyseal area</td>
<td>13.5 (10.0–17.5)</td>
<td>10.7 (7.3–14.6)</td>
</tr>
<tr>
<td>Mean (range)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance from pubis (mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bladder</td>
<td>2.2 (0.0–7.7)</td>
<td>2.3 (0.0–16.0)</td>
</tr>
<tr>
<td>Iliac artery</td>
<td>12.2 (4.9–20.6)</td>
<td>10.3 (4.6–17.1)</td>
</tr>
<tr>
<td>Iliac vein</td>
<td>5.0 (0.8–11.6)</td>
<td>3.9 (0.2–11.5)</td>
</tr>
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</table>

Table 2

<table>
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<tr>
<th>Correlations of canal diameter and body features</th>
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<tbody>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Height</td>
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<tr>
<td>Weight</td>
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* p<0.05
In women, the mean length of the pubic canal is 123.8 mm, the mean distance from the lateral ilium to the narrowest canal is 40.8 mm at the acetabulum and 118.8 mm at the parasymphyseal area. The mean canal diameter at the parasymphyseal area is 10.7 mm. The minimum and maximum canal diameters at the acetabulum are 8.0 and 14.0 mm, respectively. Thus, the safe areas for the guide wire insertion on the lateral ilium are 2.5 and 5.7 cm$^2$, respectively (2.3 times difference).

Base were positively correlated to weight ($r=0.307$, $p=0.017$ vs $r=0.264$, $p=0.038$). In women, the canal diameters at the parasymphyseal area were correlated to height ($r=0.316$, $p=0.012$) and weight ($r=0.451$, $p=0.000$). Canal diameters at the acetabulum were not correlated to height and weight (Table 2).

For insertion of a retrograde pubic screw, the guide wire should be targeted vertically in a supine position at a mean of 66º and 67º cephalad and 54.1º and 55.9º laterally for men and women, respectively. For insertion of an antegrade pubic screw, the safe area on the lateral ilium was 2.5 cm$^2$ in patients with an 8.0-mm canal diameter at the acetabulum and 5.7 cm$^2$ in those with a 14.0-mm canal diameter (Fig. 4). If a 6.5-mm cannulated screw requires a canal diameter at the acetabulum of $>8.5$ mm, 2 (2.5%) women were inappropriate for this procedure. When the minimum canal diameter required was $>10.5$ mm, 13 (16.3%) women were unsuitable (Fig. 5).

**DISCUSSION**

Retrograde or antegrade pubic screw fixation is technically demanding and risks screw misplacement even with intra-operative fluoroscopic imaging.$^5$ Cannulated screw fixation is a safer technique.$^{14,15}$ In our study, the appropriate length for the pubic screw was approximately 100 to 140 mm. Long screws with bicortical purchase provide stability and avoid screw disengagement, especially in patients with osteopenia, anticipated non-compliance, or requiring early rehabilitation.$^3,5$ Cannulated screws with long length (>100 mm) and a small diameter (<6.5 mm) are no longer available due to the risk of breakage.

Some of our patients did not have enough acetabular and parasymphyseal areas for safe placement of a 6.5-mm screw. The canal diameter should be at least around 8.5 to 10.5 mm if estimating that the bone stock around the screws should be 1 cm mm on each side. The canal diameter of the parasymphyseal area was of less importance because of absence of critical structures anterior to the bone; screws could protrude slightly anteriorly without complications. However, in the acetabular area, screw protrusion may cause joint penetration or iliac vein injury. Percutaneous screw fixation in such a small area is difficult to perform under fluoroscopy, but computer-assisted surgery can achieve a smaller margin of error.$^{10}$ Patients with an extremely narrow canal diameter at the acetabulum should not undergo percutaneous screw fixation.

The bladder, iliac artery, and iliac vein are close to the pubis. Placement of a urinary catheter affects the distance from the pubis to the bladder. The tortuosity of the vasculature (due to ageing) affects the distance from the pubis to the iliac artery and vein. To avoid injuring the iliac artery or vein, the screw should not protrude posteriorly in the parasymphyseal area and superiorly around the medial margin of the acetabulum.

In our study, the starting point for insertion of a retrograde pubic screw was the centre of the pubic

**Figure 4** In women, the mean length of the pubic canal is 123.8 mm, the mean distance from the lateral ilium to the narrowest canal is 40.8 mm at the acetabulum and 118.8 mm at the parasymphyseal area. The mean canal diameter at the parasymphyseal area is 10.7 mm. The minimum and maximum canal diameters at the acetabulum are 8.0 and 14.0 mm, respectively. Thus, the safe areas for the guide wire insertion on the lateral ilium are 2.5 and 5.7 cm$^2$, respectively (2.3 times difference).

**Figure 5** Distribution of the canal diameters at the acetabulum. Some women have canal diameters <10.5 mm.
tubercle, which enables placement of a longer screw. Others prefer it to be just lateral to the symphyseal meniscus or relatively lateral to the pubic tubercle. The shape of the anterior wall of the acetabulum is rectangular. The insertion points may slightly affect the canal diameter.

Choosing between a retrograde or antegrade approach remains controversial. Although the insertion area for the retrograde screw is small, it is just under the skin and palpable, so that the direction of the guide wire can be easily controlled. For extra-long guide wires or a specially designed guide with sharpened tips, antegrade insertion is necessary to penetrate the thick soft-tissue envelope and to facilitate placement of guide wires along the oblique surface of the pelvis. Further studies are needed to clarify the biomechanical aspects and morbidities associated with these approaches.

Preoperative computed tomographic measurement is essential to determine the indication of screw insertion. Plain radiography is confusing because of the enlargement effect due to the wide distance between the pubis and films, especially on inlet and outlet views.

CONCLUSION

Pubic screw fixation may be potentially disastrous and should be performed with caution. When the canal diameter at the acetabulum is extremely narrow, plate fixation, computer-assisted surgery, or changing to a smaller-diameter screw is recommended.

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REFERENCES