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Technical Tips

A minimally invasive periacetabular osteotomy technique: minimizing intraoperative risks

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ABSTRACT

The periacetabular osteotomy (PAO) is an extensive surgical procedure associated with potential risk to the adjacent neurovascular structures. A steep learning curve exists, with surgeon experience an important factor in outcome. Little detail exists of the osteotomies themselves, and how to make them safe and reproducible. This article describes our PAO technique with emphasis on specific safety steps. When performing the posterior column cut, migration of the osteotome beyond the lateral pelvis may lead to damage of the sciatic nerve. The safety features detailed include novel measurement of the posterior column width and the use of specific-width osteotomes to complete this osteotomy. To plan the cut, several computerized tomography-based measurements are taken starting just above the greater sciatic notch and continuing down to the inferior part of the acetabulum. The angle of this cut is determined by acetabular morphology and the width of the posterior column. These posterior column width measurements will determine the width of the osteotomes used to perform the cut with little risk that an osteotome will penetrate too far on the lateral side of the pelvis. To ensure the lateral cortex has been cut completely proximally, an osteotome with pre-measured depths may be used from a medial to a direct lateral trajectory. The senior author has been performing this modified approach since 2010 ($n = 530$ PAOs) and has witnessed no vascular injuries and no nerve injuries aside from minor lateral femoral cutaneous nerve issues. Utilization of these techniques has prevented any major nerve injury without the need for intraoperative electromyography.

INTRODUCTION

The periacetabular osteotomy (PAO) manages symptomatic hip dysplasia and other pathologic morphologies by improving hip joint mechanics [1, 2]. The technique enables a multi-planar deformity correction through a single incision [2, 3]. Excellent long-term survivorship and maintenance of functional gains have been reported when performed in appropriate patients [4–8].

The surgical aim is to obtain adequate exposure of the innominate bone to enable four separate osteotomies to be performed safely. This allows complete detachment of the acetabulum while leaving the posterior column intact. It is critical that this be achieved while minimizing the risk of intraoperative complications. Complications can be high particularly when performed by surgeons without appropriate training or while still in the learning curve [9, 10]. By understanding the anatomy around the pelvis and recognizing the structures at risk, a PAO can be performed safely and in a reproducible fashion [11].

While several descriptions regarding the technique of PAO exist, there is little detail of the osteotomies themselves, and how to make them safe and reproducible. Specific issues with the PAO are that the surgery is performed from the inside of the pelvis and it is difficult to know whether the osteotomy (apart from the transverse iliac cut) is complete on the external surface. Additionally, each osteotomy has important neurovascular structures nearby that can be injured.

Anatomic structures at risk

1. Lateral femoral cutaneous nerve (LFCN) is at risk during the entire procedure, but particularly during exposure and closure [11].
2. Obturator neurovascular structures are at risk during the ischial dissection and the pubic osteotomy.
3. Femoral neurovascular structures are at risk during the exposure of the superior pubic ramus.
4. Sciatic nerve is at risk during the ischial and posterior iliac osteotomies if the osteotomes migrate too far laterally.

This article describes our PAO technique with emphasis on specific safety steps. These steps minimize risk of iatrogenic injury without the need for an extensile surgical approach or the use of intraoperative electromyography (EMG) monitoring [12].

Pre-operative planning

In addition to a detailed history and examination, anterior-posterior (AP) pelvic and false-profile radiographs are obtained. A computerized tomography (CT) scan of the pelvis is obtained (low-dose protocol [13]) including both distal femoral condyles in order to accurately determine femoral neck anteversion.

To plan the posterior column cut (Fig. 1a and b), several measurements are taken starting just above the greater sciatic notch and continuing down to the inferior part of the acetabulum. The angle of this cut is determined by acetabular morphology and the width of the posterior column. In particular, some hips have a deep fossa and others less so; this will influence the direction and orientation of the cut. Having planned the optimal direction of the cut, the measurements will determine the width of the osteotomes used to perform the cut; with this information there is little risk that an osteotome will penetrate too far on the lateral side of the pelvis with the risk being injury to the sciatic nerve. The angle of the C-arm can also be measured to give the optimal view of the osteotome and its path down the posterior column (Fig. 1b–d).

Surgical technique

The detailed surgical technique has been described elsewhere [14]. With the skin overlying the Anterior Superior Iliac Spine (ASIS) displaced superiorly over the iliac crest, an oblique 8–10 cm skin incision is made (see Fig. 2).

A longitudinal incision through the fascia overlying the Tensor Fascia Lata (TFL) muscle belly is performed. Remaining lateral to the Sartorius-TFL internervous plane, minimizes risk of damage to the LFCN. Dissection is continued cranially over the center of the ASIS creating one sleeve containing Sartorius. The plane between rectus femoris and iliocapsularis is then developed. The periosteum is elevated along with iliacus down to the pelvic brim, remaining subperiosteal minimizes bleeding. The nutrient vessels of the iliolumbar artery may enter the iliac wing superior to the pelvic brim. Subperiosteal dissection along the pubis is then performed releasing the iliopectineal fascia from the superior pubic ramus. After developing a plane between iliocapsularis and capsule, a blunt Ganz (Depuy/Synthes) retractor is placed over the inferior extent of the hip capsule and is used to clear soft tissue from the infra-acetabular fossa ready for placement of the specialized osteotome. The osteotome position is confirmed with fluoroscopy starting on the medial side below the tear-drop. The ischial osteotomy direction is posterior remaining within the ischium but ensuring a complete osteotomy of both medial and lateral cortices. The direction on the oblique view is toward the ischial spine. The depth is determined by the point at which it will meet the planned posterior column cut. Accurate placement is confirmed by tilting the C-arm in a caudo-cranial direction and ensuring the blade of the osteotome does not protrude too far medially or laterally.

The pubis osteotomy is performed under direct vision (Fig. 3a and b). A Posterior Cruciate Ligament retractor is positioned over the superior pubic ramus medial to the iliopectineal eminence. Following subperiosteal exposure of the pubis, a medium-sized swab is positioned under the ramus protecting the obturator neurovascular bundle. Blunt retractors are then placed around the ramus. The direction of the pubic osteotomy is extremely important and should be angled in two planes: the first is the oblique direction being more lateral on the anterior border of the ramus and more medial on the posterior border and the second is that the direction should be angled away from the joint in a medial direction. By ensuring the osteotomy has this oblique orientation it allows the pubis to move medially without being blocked and so allows re-positioning of the acetabulum in an appropriate position. In the event of acetabular retroversion, there is also no block to the ramus as the acetabulum is rotated medially.

The iliac osteotomy and posterior column cuts are performed next. We prefer to start with the osteotomy down the posterior column as significant bleeding from the

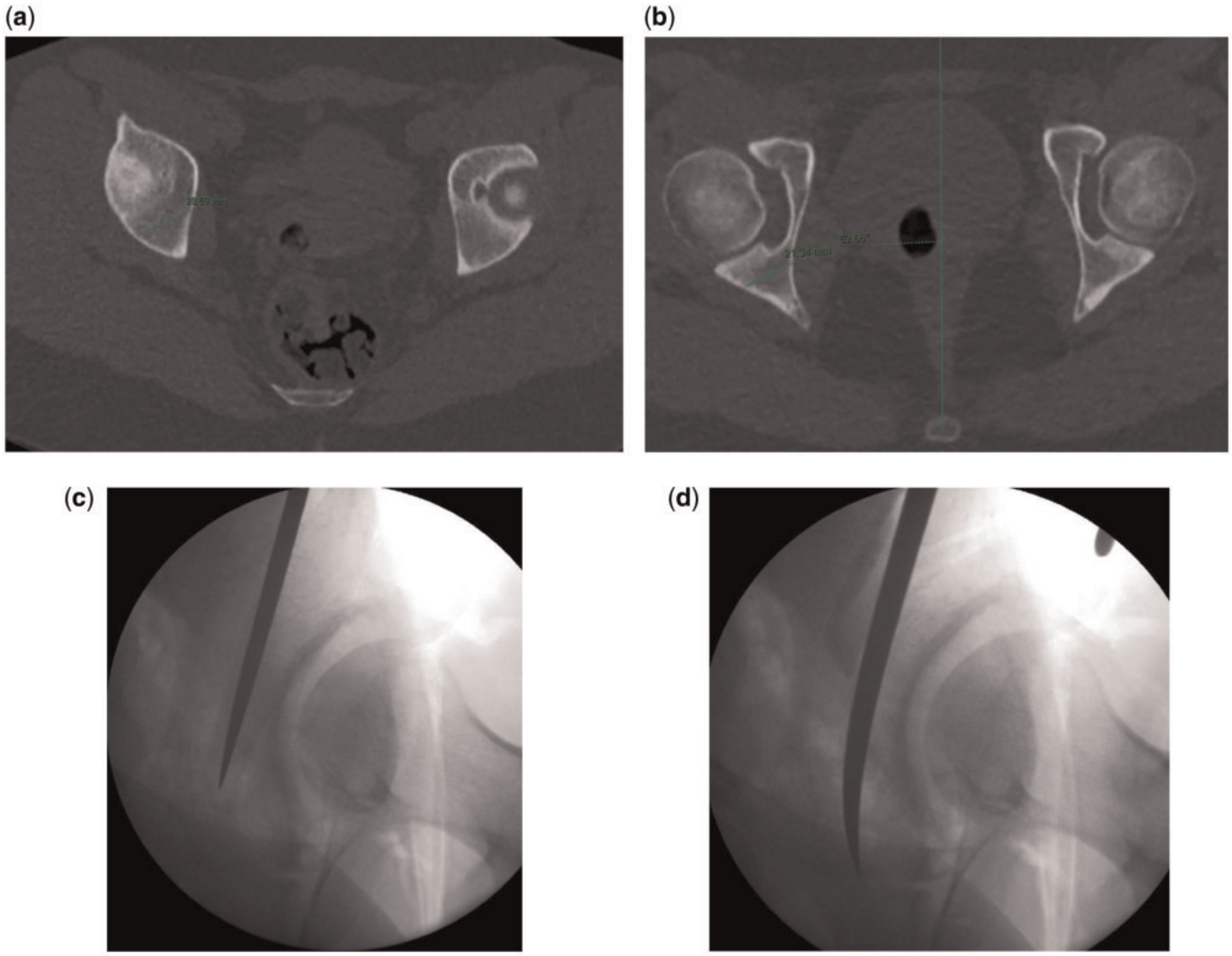

Fig. 1. Examples of the posterior column width measurement performed at two levels of the acetabulum, (**a**) cranially, (**b**) CT slice at the level of the acetabular fossa, with measurement of posterior column angle for C-arm orientation, (**c**) fluoroscopic intraoperative image of retroacetabular iliac cut on the oblique view and (**d**) fluoroscopic intraoperative image of completion of the retroacetabular iliac cut.

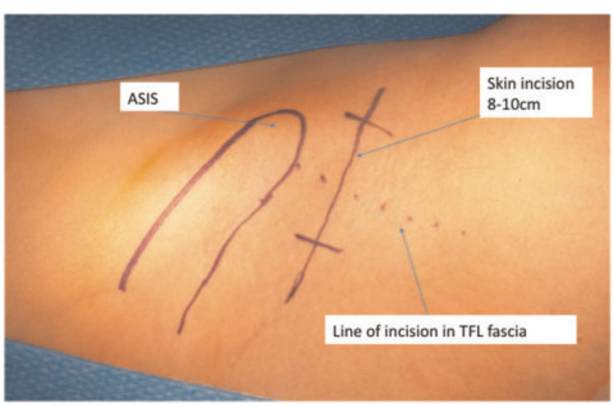

Fig. 2. The incision and surface landmarks.

nutrient vessel can occur with the transverse iliac osteotomy. The osteotomy starting position at the pelvic brim is confirmed and adjusted under fluoroscopy on the oblique view. We aim to have the osteotome parallel to the image beam according to the pre-operative CT scan measurement (Fig. 1c). We usually start with a 20-mm wide osteotome and continue down towards the ischial cut. The medial border of the osteotome should remain flush with the quadrilateral plate (Fig. 4a). In patients with hard brittle bone a small crack may be initiated extending up the iliac wing or extending posteriorly along the pelvic brim. If this occurs it is best to stop and perform the transverse iliac cut. The posterior column cut continues by using osteotomes of increasing width; usually up to 30 mm. As long as

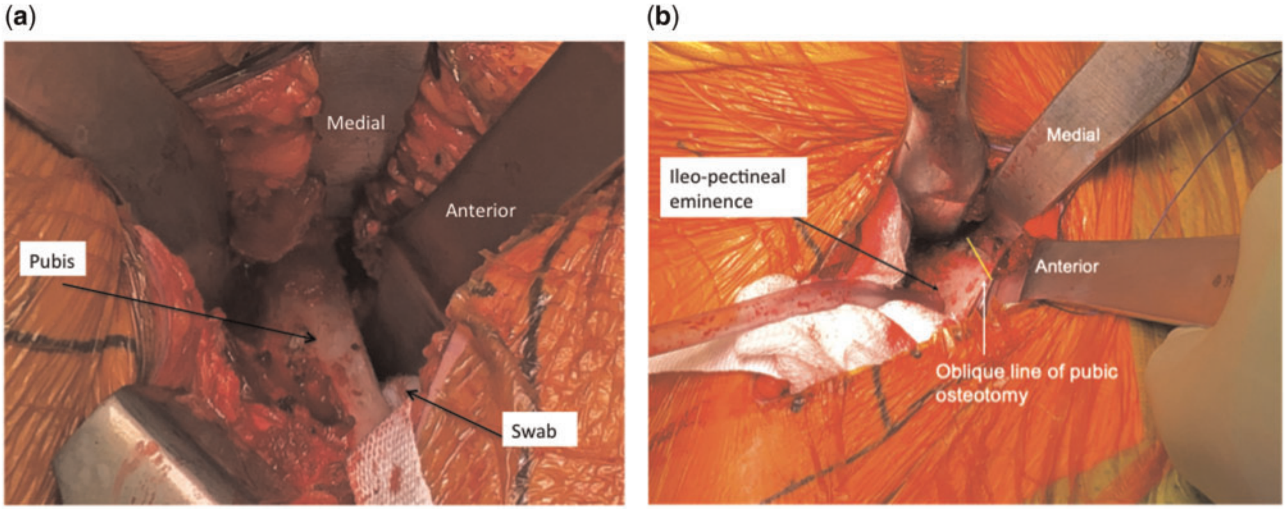

Fig. 3. (**a**) Pubis osteotomy with swab positioned on the undersurface of the pubis to protect the obturator neurovascular structures. (**b**) Orientation of the pubis osteotomy.

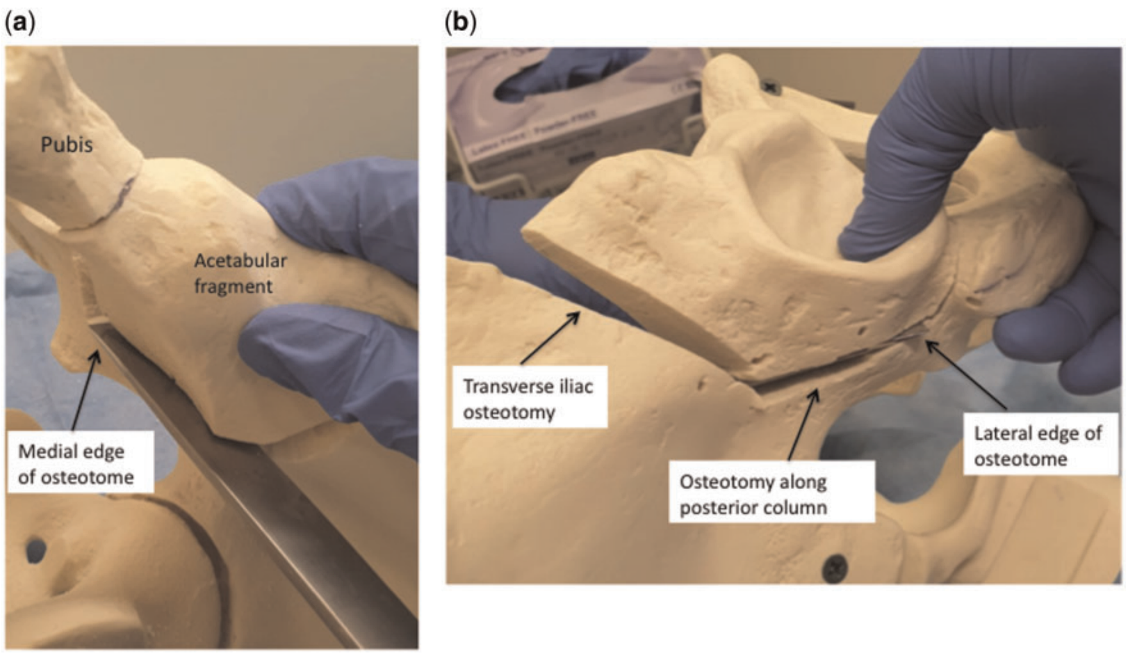

Fig. 4. (**a**) Specific-width straight osteotome seen from the medial side of the sawbone pelvis. Care is taken to ensure the medial edge of the osteotome is always seen/palpable. (**b**) Specific-width straight osteotome seen from the lateral side of the sawbone pelvis. The lateral edge of the osteotome is just visible caudally—this is an area of potential injury to the sciatic nerve.

the medial border of the osteotome is visible along the quadrilateral plate, it is known how far lateral the projection of the osteotome will be (Fig. 4b). This prevents injury to structures laterally, particularly the sciatic nerve. The nerve is most vulnerable at the proximal and lateral aspect of the posterior column cut. Maintaining a safe distance from the acetabular subchondral bone also prevents intra-articular fracture propagation. The osteotome is kept mobile to prevent it getting wedged and potentially causing fracture propagation. To ensure the lateral cortex has been cut completely proximally, a curved osteotome with pre-measured depths may be used from a medial to a direct lateral trajectory.

The transverse limb of the iliac cut is then performed. This is performed with a saw after creating a space on the outer aspect of the pelvis. It is important to ensure that there is sufficient bone between the iliac cut and the acetabulum to allow fixation. It may not always be possible to meet the ischial cut with a straight osteotomy. A curved osteotome of different widths is used to continue the distal part of the posterior column cut to meet the ischial cut.

The osteotomy is opened at the transverse iliac cut and bone wax placed at the confluence of the transverse and longitudinal limbs to minimize bleeding. Upon satisfactory reorientation, the acetabular fragment is secured with two 2 mm threaded guide wires, and definitive fixation is usually with three 4.5 mm cortical screws. Knee flexion allows proximal excursion of the skin incision for screw placement.

SUMMARY

The PAO is an extensive surgical procedure associated with potential risk to the adjacent neurovascular structures. A steep learning curve exists, with surgeon experience an important factor in outcome [9, 10]. To minimize complications, the senior author has developed several strategies during the procedure. He has been performing this modified approach since 2010 ($n = 530$ PAOs) and has witnessed no vascular injuries and no nerve injuries aside from LFCN issues. The safety features detailed include novel measurement of the posterior column width and the use of specific-width osteotomes to complete the iliac retroacetabular cut. Utilization of these techniques has prevented any major nerve injury without the need for intraoperative EMG.

CONFLICT OF INTEREST STATEMENT

None declared. The data associated with this paper can be accessed via the corresponding author.

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