MINI-SYMPOSIUM: CHILDREN—OSTEOTOMIES AROUND THE HIP

(i) The Salter innominate osteotomy

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Summary
The Salter osteotomy has stood the test of time, proving to be a safe and effective means of improving acetabular cover in the younger child. Alternative procedures are briefly discussed and technical aspects are described.
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Introduction
Establishing a stable femoral head is an essential element in treating the dysplastic hip joint after reduction. In the infant up to the age of 18 months an unobstructed replacement of the femoral head deeply within the acetabulum will usually produce satisfactory acetabular growth and deepening. Provided that congruity improves and concentric movement is achieved, further treatment may be unnecessary. Adequate femoral head cover should be demonstrable by 3–4 years of age.

The decision-making process is somewhat arbitrary but is based upon

(1) the clinical appearances of the hip, since any spasm or limited motion is of concern, particularly if associated with asymmetry of the leg producing the appearance of "skeletal skew" and
(2) radiographic improvement including an acetabular index of 30° of more after the age of 3\(\frac{1}{2}\) years; lateralisation of the femoral head radiographically can be measured using the centre-head distance.\(^1\)

The latter can only be used in unilateral cases, a distance of more than 6% at the age of 4 or 5 years indicating that supplementary surgery may be necessary.

In the toddler older than 18 months full development of the acetabulum after femoral head reduction is less assured. The acetabular response becomes unpredictable and stability of the femoral head after reduction is harder to ensure when both acetabular inclination and deformation of the femoral head may prevent congruent reduction. Nevertheless, it is important that Salter’s prerequisites are met,\(^2\) namely that the hip should present with a free range of movement, whether following previous treatment (Fig. 1) or presenting de novo with dysplasia (Fig. 2). He also stated that any reduction achieved after complete dislocation should be reasonably congruent at the time of the osteotomy.

Timing of the osteotomy
Deciding when to undertake the Salter osteotomy, in relation to open reduction the hip in the slightly older
child, is a matter for some debate. Concurrent innominate osteotomy makes further surgical operations less likely, additionally helping to stabilise the femoral head. It has been suggested that the outcome after simultaneous open reduction and osteotomy may not differ markedly from a staged procedure and there is a legitimate concern that both redislocation and avascular necrosis are more likely if the procedures are combined. A more recent paper revealed that in a series of 188 Salter osteotomies the best results occurred in children under the age of 30 months, treated by the combined procedure. Staged operations yielded a slightly smaller proportion of satisfactory results (71 per cent versus 89 per cent in the younger child) but the risks of redislocation and avascular necrosis were reduced.

Deferring the pelvic osteotomy for some time after the hip has been reduced may of course allow a gradual subluxation of the femoral head before the acetabulum is redirected. Whichever approach is favoured, it is paramount that the capsulorrhaphy in the concurrent procedure is carefully rendered and that the acetabular inclination is reduced by at least 15° by the osteotomy. Femoral shortening is often required after the age of 2–3 years, especially in the high dislocation. A useful discriminant in the operating theatre is to reduce the femoral head, after an adductor tenotomy, with the knee flexed (to relax the hamstrings) and with the thigh slightly internally rotated. If the femoral head redislocates as the knee is straightened and the thigh returns to a position where the knee is pointing anteriorly, femoral shortening is indicated. When femoral head reduction cannot be achieved without proximal femoral osteotomy and overlapping of the femoral shaft, then clearly a femoral shortening of some 1–2 cm is essential.

In bilateral cases the Salter osteotomy should only be undertaken sequentially. Unless one or other femoral head is very unstable after open reduction in these cases, the Salter osteotomy is undertaken some time after closed or open reductions have been achieved. Concurrent, bilateral

**Figure 1** A sequence of radiographs with staged open reduction of the left hip and subsequent Salter innominate osteotomy.
innominate osteotomies are only indicated in cases of bladder extrophy as a means of producing adventitial cover anterior to the bladder.

If the femoral head lateralises after the Salter innominate osteotomy, or if the acetabular dysplasia is poorly corrected, the outcome will be impaired. Varus and/or derotational proximal femoral osteotomy may be required. Further open reduction and capsulorrhaphy are sometimes indicated but repeating the Salter procedure is not advisable. An augmentation shelf graft, Dega procedure\textsuperscript{7,8} or a Chiari osteotomy\textsuperscript{9–11} may help to provide stability. As the Salter osteotomy rotates the acetabulum anterolaterally over the femoral head, a misshapen femoral head or acetabular deformation will adversely affect the result. The Pemberton (or "Pembersal"\textsuperscript{12,13}) tends to lateralise the hip joint and increase articular pressure. In the older child and adolescent, it is increasingly difficult to rotate the lower pelvic segment at the symphysis pubis. Therefore, the Ganz,\textsuperscript{14} Steel\textsuperscript{15} or Tonnis\textsuperscript{16} procedure are indicated, although technically more invasive.

**Technique**

The stages of the Salter osteotomy have been described previously in Current Orthopaedics\textsuperscript{17} but merit a brief outline. Practical experience of the procedure can only be gained by supervised operating in theatre, repeated regularly. Fuller accounts of the osteotomy are recommended for those with a developing interest in children’s orthopaedics.\textsuperscript{1,3,18,19}

**a. Position of the child**

i. a sandbag is used to tilt the child up on the operation side, but this should be placed under the flank and not the buttock,
ii. the child should be near the side of the table to facilitate access,
iii. the C-arm of the image intensifier is draped and positioned transverse to the child on the contralateral side; at least one operating surgeon should wear a lead apron.

b. Incision

i. the transverse (bikini line) ilioinguinal skin incision is centred a finger breadth below the anterior superior spine ($\frac{1}{2}$ medial to the spine and $\frac{2}{3}$ lateral to it),
ii. the plane between tensor fascia lata and sartorius is developed distally and then dissected proximally,
iii. the iliac apophysis is split down to bone by a sharp incision over the anterior 3–4 cm, cracking open and then reflecting the apophysis away from the iliac wing subperiosteally (Fig. 3),
iv. the wayward lateral femoral cutaneous nerve should be protected if possible.

iv. the plane between tensor fascia lata and sartorius is developed distally and then dissected proximally,

v. if the head of the femur redislocates after reduction it may be necessary to carry out a proximal femoral shortening, with correction of any significant femoral anteversion,
vi. a tight capsulorrhaphy is the most important component of the operation, either by double-breasting the capsule or by excision of the redundant capsule.

d. The innominate osteotomy

i. access subperiosteally to the sciatic notch must be careful to avoid sciatic nerve damage or major haemorrhage,
ii. Watson-Jones bone levers are inserted "on the side" to give posterior space and a curved (90°) gall bladder (Moynihan) forceps (Fig. 4) is inserted around the sciatic notch, either medial to lateral or lateral to medial, whichever is easier; suction and a well-directed light are essential,
iii. the Gigli saw will pass round the back of the ilium more readily if the loop end of the saw is narrowed and bent to conform around the notch (Fig. 5),
iv. the saw is encased in plastic gastric tubing on either side of its cutting, central segment,
v. this protects the soft tissues as the saw is moved back and forth; during cutting, the hands should be kept apart and tension maintained evenly (Fig. 6),

Figure 3  The extent of the incision (top left) $A =$ anterior iliac wing, $P =$ proximal thigh, splitting the iliac apophysis (I) (top right), a periosteal elevator (P) allows the iliac wing to be exposed subperiosteally (bottom left), a blunt hook (B) lifts the iliopsoas (I) near the anterior inferior iliac spine (A) (bottom right).
vi. anteriorly, the osteotomy can be finished with an oscillating saw if the Gigli saw binds in bone.

f. Displacement of the osteotomy

i. when correcting acetabular dysplasia alone, with no need for reduction and capsulorrhaphy, placing the leg in the "figure 4 position" (thigh abducted and externally rotated, knee flexed) will aid in opening the osteotomy anteriorly and directing the lower pelvic fragment laterally.

ii. redirection of the lower fragment is better achieved with a towel clip in the anterior inferior iliac spine, an osteotome "on the flat" pressing down on the lower fragment when the capsule has been opened, and the insertion of a Lambotte hook (Fig. 7),

iii. triangular metal templates (Fig. 8) allow displacement of the osteotomy to be gauged and the size of the graft to be estimated.

g. Bone graft

i. the triangular graft is procured from the anterior iliac wing or further back (Figs. 9 and 10),

ii. the graft is carefully trimmed to give squared off edges, inserting it with sequestrum forceps and opening up the anterior osteotomy as fully as possible,

iii. bank bone or bone substitutes may be preferred.

Figure 5  The loop end of the Gigli saw is narrowed and curved, allowing it to be held by the forceps with gastric tubing encasing the saw to prevent soft tissue abrasion.

Figure 4  Gall bladder forceps (90° curve) with the Gigli saw and leader cord.

Figure 6  The innominate osteotomy is undertaken with the Gigli saw from posteriorly to anteriorly, keeping the lateral hand more distal than the medial hand so that the cut is at right angles to the ilium.
h. Graft fixation

i. two or three (threaded) K-wires are inserted from above, through the iliac wing,
ii. the depth of the wire insertion is checked against a similar K-wire, held parallel to the track of the fixation wire,
iii. it is important to check femoral head movement in the acetabulum, or, if the femoral head is out of the socket, to palpate the articular surface for possible protrusion,
iv. image intensifier views are helpful at this stage,
v. the wires should be left slightly prominent under the skin for removal at six weeks postoperatively when the hip spica cast is taken off under a general anaesthetic,
vi. the use of cannulated screws or Biofix absorbable rods is not recommended.

i. Soft tissue closure

i. the apophysis should be accurately apposed,
ii. the lateral femoral cutaneous nerve must not be trapped by any suture,
iii. after irrigation, skin is closed with a subcuticular suture.

Figure 7 The small Lambotte hook (beside the gall bladder forceps) is inserted behind the distal pelvic fragment, pulling it forwards. A gap is developed at the anterior end of the osteotomy with the towel clip and hook in place, allowing a carefully sized template and similarly proportioned bone graft to be readied for insertion.

Figure 8 The metal template has been inserted in the osteotomy gap and can be checked radiographically before inserting the graft and 3 K wires.
j. Plaster spica

i. an adjustable spica table should be used if possible (Fig. 11),

ii. the stockingette is pre-stitched and fits the child accurately (Fig. 12),

iii. excessive padding should be avoided if both orthopaedic felt and wool are usually required (Fig. 13),

iv. plaster of paris or synthetic materials are used for the spica which should be carefully moulded around the greater trochanter to hold the femoral head secure (Fig. 14).

Figure 9 The iliac wing is exposed using Watson–Jones levers before obtaining the bone graft with bone cutters or an oscillating saw.

Figure 11 The adjustable hip spica table with orthopaedic felt in readiness.

Figure 12 The stockingette is cut and stitched to produce a skin tight fit.

Figure 10 The dimensions of the triangular bone graft are measured out as shown.
Complications

Complications include general misadventures such as sciatic and femoral nerve injury, entrapment or damage to the lateral femoral cutaneous nerve, arterial bleeding, bladder retention, infection and pressure sores. The technique of the Salter innominate osteotomy is prone to some specific complications, such as avascular necrosis of the proximal femoral epiphysis and/or stiffness of the hip (often with an abductor contracture), absorption, K-wire migration and difficulty in removal, redisplacement of the femoral head, bone graft collapse or derelination, infection and pressure sores.

Further specific complications of the procedure include redisplacement of the femoral head, bone graft collapse or absorption, K-wire migration and difficulty in removal, stiffness of the hip (often with an abductor contracture), avascular necrosis of the proximal femoral epiphysis and/or growth plate, and lateralisation of the hip subsequent to capsulorrhaphy. A less recognised but important complication is elongation of the affected leg, both from the stimulus of closed or open reduction and the subsequent Salter innominate osteotomy. This is evident in almost 80 per cent of children after late dislocation and can be as much as a centimetre of overgrowth in almost a quarter. Various questions arise in relation to the technique of osteotomy. For example, how does one determine congruency and concentric movement of the femoral head within the acetabulum? Arthrography may be useful in this context. Should the pelvic realignment and graft fixation precede or follow femoral head reduction into the acetabulum? Are the guidelines for femoral shortening sufficiently strict? And finally, is minimal access surgery a safe advance?

Conclusion

The Salter osteotomy offers an effective means of improving acetabular alignment and femoral head stability but should not be considered in the younger child until the acetabulum has shown its ability to improve. Various modifications of the procedure have been described but the essential factor is that the surgeon should be familiar with the osteotomy and that attention to detail must be meticulous.

References
