CASE REPORT
Re-ossification of the pelvis following hemipelvectomy for trauma

G. Wansbrough, N. Boyne, C. W. Pollard
From Royal Brisbane and Women's Hospital, Herston, Australia

We present a patient who underwent delayed sub-periosteal hemipelvectomy for control of infection and to enable soft-tissue cover after trauma. At four months after amputation, clinical examination and radiographs demonstrated almost complete re-ossification of the hemipelvis. This has allowed the patient to regain sitting balance and to use a walking prosthesis designed for patients following disarticulation of the hip. After 14 months from injury, no perineal hernia has developed, and no dysfunction of pelvic organs is attributable to heterotopic bone formation or adhesions.

The patient’s mobility with a prosthesis is similar to that expected of a through-hip amputee.

Traumatic hemipelvectomy is uncommon, accounting for 0.5% of fractures of the pelvis, with a mortality rate of greater than 60%. The incidence of patients with such injury surviving to reach hospital is increasing because of improved pre-hospital care. If the patient survives the acute injury, long-term complications include rectal and genitourinary dysfunction, pelvic hernia and a prosthetic challenge to address mobility and sitting balance. The physical function and quality of life in hindquarter amputees after excision for tumours is poor, with only 24% using their prostheses on a regular basis. Their walking speed is 50% to 60% of that of normal subjects and energy consumption is increased by between 80% and 125%.

Case report
A 23-year-old construction worker was run over by a reversing caterpillar-tracked excavator, the tracks reaching the costal margin before the machine was driven off. He sustained massive crush injuries to the pelvis, the left lower limb, the pelvic organs and an extensive wound of the left groin through the femoral neurovascular bundle, extending from the left anterior superior iliac spine to the perineum, exposing the rectum. Immediate compression was applied to the wound at the scene, a pelvic binder was placed for pelvic stability and volume control, and the patient was rapidly transported to a level one major trauma centre 3 km away. After a brief stay in the emergency department for insertion of a second intravenous line, basic radiological examination and the implementation of the massive transfusion protocol, the patient went straight to the operating theatre, with permissive hypotensive resuscitation until then. Manual compression was applied to the wound in the groin, while the initial laparotomy for damage control was performed.

The injuries included a ruptured bladder, an extensive pelvic haematoma, a laceration of the posterior urethra, left femoral neurovascular avulsion, extensive soft-tissue damage and a deep de-gloving lesion extending from the open wound, over the lumbar spine beyond the midline and to the level of the thoracolumbar junction. Radiographs revealed a massive open pelvic fracture (Fig. 1). At laparotomy, the left external iliac artery was found to be avulsed...
and was ligated after the decision was made not to attempt salvage of the limb. Both internal iliac arteries were also ligated in an attempt to control the haemorrhage, but despite this, bleeding was brisk from multiple inaccessible vessels. Packing of both the intra-peritoneal space and the extensive groin wound with temporary skin closure achieved successful tamponade. The bladder was repaired over a supra-pubic catheter and a loop ileostomy was performed before closure. The following morning the hip was disarticulated. The wound in the groin was debrided and repacked.

Closed reduction and percutaneous stabilisation of the sacroiliac joint was undertaken on the second day after injury. Although trans-iliac-trans-sacral stabilisation from the right was considered, separate screws were used to allow further independent management of the hemi-pelvises. The screw inserted from the left passed through intact skin and viable muscle.

On day seven, after a further interim debridement, in response to systemic sepsis, infected smelling tissue was detected deep to the sciatic notch and the skin overlying the hemipelvis was compromised. In order to achieve adequate debridement, reduce the volume of the hemipelvis and improve soft-tissue cover by the remaining gluteal tissue, the left hemipelvis was excised. After removal of the left sacro-iliac screw, the innominate bone was shelled out from its periosteum (Fig. 2).

Over the subsequent 30 days, eight further debridements of the pelvis and gluteal flap were undertaken with further loss of soft-tissue cover. At the last of these operations, the wound was covered with a split skin graft and vacuum-assisted closure dressing. A decision not to attempt open reduction and internal fixation of the right hemipelvis was taken. Subsequent surgery included closure of the ileostomy and anastomotic urethroplasty. Further surgery will include penile implants and possibly an artificial urethral sphincter.

The patient mobilised in a wheelchair for 12 weeks, before weight-bearing through the right hemipelvis. Thereafter he entered into a programme of physical rehabilitation, progressing from parallel bars to crutches as balance and strength allowed. At eight weeks after skin grafting, he was fitted with a sitting prosthesis and was able to drive a car.

The healing and stability of the pelvis was monitored physically and radiologically. Unexpectedly, hardening was noticed beneath the soft tissues overlying the left pelvic region and florid formation of new bone throughout the hemipelvis was observed on radiographs (Fig. 3). The anatomical position and form of this bone closely mirrored the contralateral side, including the iliac crest, pubic rami, symphysis and ischial tuberosity. These features proved valuable for the fitting of a walking prosthesis.

An Otto Bock (Duderstadt, Germany) modular walking prosthesis was fitted 13 months after injury using Helix 3D Hip, C-leg (knee) and Axion foot components. Brisbane Prosthetics PTY Ltd (Tugun, Queensland, Australia) were able to manufacture an abbreviated half socket using a custom-made silicone liner (Evolution Industries, Orlando, Florida), a design specifically for use following disarticulation of the hip, and suspension was achieved over the iliac crest alone. In particular, by virtue of the transfer of the body weight through the neo-ischium, pistoning of the prosthesis was minimised, which allowed close matching of the limb lengths, minimisation of pelvic tilt through the gait cycle (Fig. 4), and improved tactile feedback and control for the patient. After six weeks he was able to walk up and down stairs, and began an apprenticeship as a chef.

**Discussion**

Re-ossification of the innominate bone appears to have been due to retention of the overlying periosteum at the time of excision. The pelvis is known to be rich in...
osteogenic precursor cells in young adults, and it is likely that the periosteum is rich in these cell lines. Formation of new bone from the periosteum may occur through either appositional or intramembranous ossification. Remodeling of adult bone with proliferation of pre-osteoblasts and osteoblasts from the deep surface of the periosteum was demonstrated in roosters by Pead, Skerry and Lanyon. These cells may have resulted from de-differentiation of, or direct conversion from periosteal lining cells, and is the process of appositional ossification. Aaron and Skerry observed migrating arrays of coarse collagenous fibres produced from the endosteum of the pelvis in sheep after 1 cm excision biopsies of bone, which subsequently supported intra membranous re ossification. We believe that the latter mechanism is the most likely in our case as appositional or intramembranous ossification. The prosthetic approach has been as for a disarticulation of the hip with suspension of the prostheses over both iliac crests and weight-bearing through the reformed ipsilateral ischial tuberosity. This has enabled the use of an abbreviated half socket, usually reserved for patients with disarticulation of the hip. The advantages of this prosthesis include the fact that the socket/suspension system does not need to extend to the contralateral ischium or the costal margin, and is therefore lighter, allows freedom of movement and encloses less skin, reducing dermatitis, perspiration and discomfort. The fitment is also more stable: sockets which bear on the contralateral ischium are difficult to keep in place, and usually require frequent adjustment. Reduced pistoning allows ground clearance in the swing phase with more equal leg lengths. This reduces the pelvic tilt through gait (and possibly back pain), and improves cosmesis. Furthermore, the prosthesis is not required to be as tight as a pelvic bucket within which the soft tissues must be pressurised to minimise pistoning, improving comfort. Overall, patients with an intact hemipelvis are more tolerant of the weight of a lower limb prosthesis, which increases with its sophistication and functional capabilities. However, significant reduction in energy consumption has not been demonstrated. Skin graft was applied to areas of soft tissue of the perineum which have subsequently ossified. This area is involved with weight-bearing without protection from the normal gluteal muscular bed. Although primary healing of the graft was uneventful, subsequent localised breakdown has occurred once, requiring modification of the sitting prosthesis and careful monitoring. The graft may be more susceptible to ulceration as a result of the underlying ossification, and if the skin graft does not become more resilient, long-term management of the area may involve an advancement of vascularised muscle flap, or the use of a tissue expander. 

Further reconstruction of pelvic organs has been required since re ossification of the pelvis by both general and uro logical surgeons. They have not encountered additional technical difficulties due to the formation of new bone.
Herniation of pelvic organs is a rarely reported complication of hemipelvectomy that has not occurred in this case, and we believe is unlikely because of the re-ossification. The remaining periosteum may be important in supporting and nourishing the overlying skin graft, although it becomes an unforgiving host after ossification. We consider that every effort should be made to achieve muscular cover of the periosteum with a flap if necessary before skin grafting.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References