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Computer Navigated Percutaneous Sacroiliac Joint Screws Assisted by Caudal Epidural Contrast Injection

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Abstract

This article describes an innovative technique for effective analgesia and enhanced accuracy in placement of percutaneous sacroiliac screws in patients with unstable, posterior pelvic ring injuries. Our approach involves introducing radio-opaque contrast through an indwelling caudal epidural catheter to enhance existing computer navigation systems. This delineates the lumbosacral nerve roots to promote the safe and accurate placement of sacroiliac screws and concurrently provides effective analgesia. We describe the technique and our first cases. It can be used to supplement your current technique in placing sacroiliac joint screws and provide effective analgesia for our patients.

Keywords: Navigated; Sacroiliac; Fractures; Screws; Epidural; Contrast

Introduction

Effective analgesia and early fixation allow early mobilisation and may decrease the long term sequela associated with these serious high-energy injuries [1]. Placement of percutaneous sacroiliac joint (SIJ) screws is technically challenging with the potential for injury to adjacent neurovascular structures, in particular the lumbosacral nerve roots [2-6]. Several studies have demonstrated the close proximity of iliac vessels and the lumbosacral nerve roots, with injuries recorded to these structures as a result of screw placement [2-5,7]. Traditionally, screws are placed using two-dimensional fluoroscopic imaging. The disadvantage of this method is that only one plane can be viewed at a time leading to frequent rotation of the image intensifier and long fluoroscopy exposure times [4,8,9].

Existing computer navigated techniques are used in our unit to aid accurate screw positioning in the safe bony triangle [4,8,10]. However, with a narrow target zone and neurovascular structures in close proximity, the potential for screw malposition and neurovascular injury still exists [7,11,12]. Despite fluoroscopic navigation, data from the German trauma registry showed a surgical complication rate from sacroiliac screw fixation in the region of 8% to 10% [11]. Other studies have shown neurological insult from screw placement in the order of 0.5% -7.7% [7,13,14]. This is in part due to narrow safe zone for screw placement with the resultant low margin for error [2-4,6,7]. Several anatomical studies have demonstrated the proximity of the iliac vessels and lumbosacral nerves to the course of the screw path [2,3,7]. Temple man and co-authors demonstrated a safe window width of 21.7 mm for S1 screw placement; with a four degree window of error before sacral foramen or anterior cortex are threatened [7]. The fifth lumbar nerve root, the first sacral foramen and median sacral vessels have been compromised in previous studies of iliosacral screw placement [3-5].

We have modified our standard navigated technique to include the introduction of analgesic agents and radio-opaque dye through a caudal epidural catheter to delineate the adjacent lumbosacral nerve roots, and enable real time visualization of these structures during screw placement. Additionally providing non-opioid based direct analgesia to the target structures. In the long term we hope this technique will decrease the rates of iatrogenic nerve root injury as well as the incidence and intensity of chronic pain.

Patients who suffer unstable fractures of the pelvis are prone to a stormy perioperative period secondary to poorly controlled pain, a predisposition to complications, and prolonged immobilization [1]. The long-term outlook is traditionally also comparatively poor, typified by chronic pain, psychosocial dysfunction and economic consequences [15-17]. Early fixation has been shown to improve the long term outcomes [1]. We aim to improve the accuracy of early fixation and concurrently provide effective targeted analgesia by combining existing navigated SIJ screw placements with a lumbosacral catheter. We describe the technique and our first cases.

Methods

All patients were treated at one Institution, Sir Charles Gairdner Hospital in Perth, Western Australia. We have a coordinated multidisciplinary approach involving the Radiological, Anaesthetic and Orthopaedic departments in conjunction with allied health and nursing staff.

Pre-operative care

Patients are prophylactically protected from thromboembolism by the administration of low molecular weight heparin and the insertion of an inferior venae cava (IVC) filter. This is placed by our experienced Interventional Radiology Department. Pre-operatively an indwelling catheter (IDC) is placed to empty the bladder.

Technique

An Anaesthetist skilled in the management of chronic pain inserted the caudal epidural catheter and injected the contrast in all of the described cases. A caudal epidural catheter, in this case a 16 g Portex Epidural catheter, was inserted 10 cm under ultrasound guidance. A mixture of 20 ml 0.1% Ropivacaine and 5 ml of a radiopaque contrast agent (*Isovist* was used in this case) is then injected to surround the S1 nerve root. Figure 1 demonstrates the insertion of the catheter pre-operatively.

Our existing fluoroscopy based navigation system (Stryker

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TraumSubject: A Navigation) is used and enhanced by the nerve root delineation achieved by the contrast injected in the catheter. The resultant intraoperative fluoroscopy is demonstrated in Figures 2 and 3 display the same fluoroscopy image with the nerve roots and vertebral bodies outlined. We confirm the position of the screw at the level of the SIJ on image intensifier, prior to advancing the full screw path. Additional contrast can be infused using the catheter as required during the case.

Figure 1: Insertion of caudal epidural with ultrasound guidance.

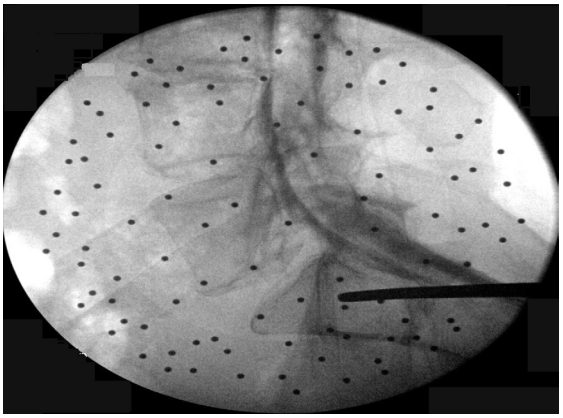

Figure 2: Fluoroscopy of lateral X-ray with addition of contrast to delineate nerve roots. Drill entry point posterior to iliac-cortical density shown.

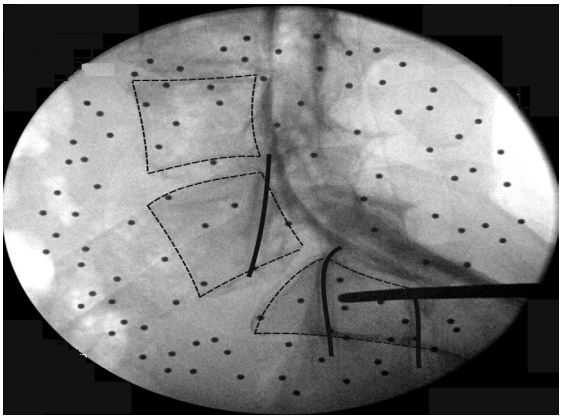

Figure 3: Nerve roots and vertebrae outlined. Drill entry point posterior to iliac-cortical density shown.

Hours post-op	Mean VAS pain score (0-10)
2	1
12	1
24	4
36	2
48	1

Table 1: Mean VAS pain scores post-operatively.

Post-operative care

The patient is seen by the acute pain service of our hospital that manages analgesia requirements utilizing the existing caudal epidural catheter and other conventional methods. In particular patients had access to an intravenous hydromorphone patient controlled analgesia (PCA) pump system, regular doses of meloxicam, gabapentin and paracetamol. The catheter remained *in situ* for a maximum of 72 hours. Reduction of the fracture and screw placement was confirmed with a CT scan post operatively. Once reduction was confirmed patients were mobilized with protected weight bearing for six weeks.

Warfarin was commenced post operatively and continued until removal of the IVC filter typically at 2-3 months.

Results

We are encouraged by early results of patients undergoing this procedure. In the 3 patients we have performed the technique on there have been no nerve root injuries and no screws have needed revising. Patients suffered high-energy injuries as a result of motor vehicle injuries and one experienced a fall from a 4m height. Patients have been followed to a minimum of 12 months. Median age was 33 (20-57).

Our experience has been more comfortable patients in the immediate post-operative days allowing early mobilization. Patients mobilized with physiotherapy at a mean time of 48 hours post operatively. Mean visual analogue scale (VAS) pain scores (0-10) for the series are outlined below in Table 1.

The technique is a useful adjunct to improving the confidence of this technically demanding procedure. It can be used to supplement your current technique in placing SIJ screws and provide effective analgesia for your patients.

Discussion

Percutaneous sacroiliac screw placement is challenging and associated with complications [4,11,18]. It can be made more difficult by intraluminal bowel gas and obesity [19]. Traditionally, fixation of these fractures was delayed until clearance of the ileus that can occur as bowel gas patterns can obscure fluoroscopic landmarks vital for safe placement of a SIJ screw [5].

Fluoroscopic based computer navigation systems have been used to improve the precision of sacroiliac screw placement in an area with neurovascular and viscera in close proximity [4,10,14,20-22]. It has also been shown to allow longer screws to be placed with the improvement in accuracy [20]. Improved accuracy has permitted earlier fixation that has been shown to provide improved outcomes [1,19,23]. Navigation systems have also shown to reduce fluoroscopy time and therefore radiation exposure compared to standard fluoroscopy [4,8,9].

Early fixation reduces the length of prolonged bed rest and its associated complications such as thromboembolism, pressure sores, urinary tract infections and distress [1,23]. Latenser et al. demonstrated early fixation of unstable pelvic fractures had a significant reduction in chronic pain, need for transfusions, pulmonary complications, and

obstetrical problems in female patients and lessened the incidence of gait abnormalities [1]. In addition, adequate reduction of pelvic fractures has been shown to be more difficult after as little as three days following the fracture [24]. There are other benefits of early fixation to simplify nursing care and permit early mobilization thus reducing the sequela of immobility [1,23]. We believe that our technique assists in increasing the safety of early posterior pelvic ring fixation.

Patients who sustain pelvic ring injuries are typically young and active at the time of injury [25]. They often suffer multiple injuries secondary to high-energy trauma. They are poorly resourced to deal with becoming dependent and immobile [18]. Previous studies have demonstrated the lasting effects on function and wellbeing following these injuries and the associated economic costs [15,18].

Despite accurate radiological reduction and fixation of posterior pelvic ring fractures, a significant proportion of patients continue to have ongoing functional impairment and chronic pain [16]. Less than 50% return to their pre-injury functioning and employment despite near anatomical reduction of fractures [16]. We propose that improved perioperative pain control may improve these outcomes.

Previous studies have established the efficacy of using regional anaesthesia via peripheral catheters to reduce peri-operative pain levels and narcotic use [26]. The use of regional anaesthesia is well accepted during elective orthopaedic procedures. Our approach utilizes a caudal epidural catheter that has the dual effect of delineating anatomy and providing peri-operative pain relief. The innervation of the SIJ has been described by several authors, without consensus, as stemming from dorsal rami of L5-S3, most commonly cited S1-S3 [27]. We target these nerve roots with our technique.

We hope to improve long-term pain and function outcomes by better controlling peri-operative analgesia with the caudal epidural. This patient group is difficult to investigate the isolated outcome of an intervention due to the heterogeneous nature of the injuries treated and the presence of other injuries in the multi-injured patient. This has previously been discussed by other authors [25].

Conclusion

Using a caudal epidural catheter for preoperative pain relief and to delineate pertinent neurological anatomy builds on existing navigation techniques for SIJ screw placement. It is hoped this technique will reduce rates of nerve root injury and chronic pain, improving outcomes for this patient group.

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