Visualization of lumbosacral nerves during anterior sacroiliac plate fixation using navigation system: a case report

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Introduction: Treatment of unstable pelvic ring fracture has evolved to be more aggressive because early, anatomic and stable internal fixation of pelvic ring allows early recovery and decreased morbidity and mortality. Pelvic ring fracture of type C according to the AO-OTA classification has posterior pelvic ring disruption, which result in rotational and vertical instability. Anterior fixation of the sacroiliac joint with a plate has gained general acceptance as a technique to rigidly stabilize posterior disrupted joint. This technique has an advantage in avoiding soft tissue problem in the buttocks, while it requires detailed anatomic knowledge and extensive surgical experience. Safe and reliable area for screw fixation in sacral ala is narrow because of limited bone stock and intra-osseous sacral nerve root. In the extra-osseous area, the L4 nerve branch, L5 nerve root and lumbosacral trunk exist close to the sacroiliac joint that may be injured during the procedure. In addition, there exist wide variations in the distance between lumbosacral nerves and sacroiliac joints. We hypothesized that visualization of lumbosacral nerves on the navigation monitor could assist surgeons to perform safe and reliable anterior sacroiliac plate fixation. We report the first case of type C pelvic ring fracture treated by anterior sacroiliac plate using the CT-based navigation, which visualized lumbosacral nerves as well as iliac and sacral bones.

Case Report: A 49-year-old woman was involved in a traffic accident. Anteroposterior (AP) radiographic views of the pelvis showed dislocation of the left sacroiliac joint with a crescent fracture and ipsilateral superior and inferior pubic ramus fractures. The left hemipelvis was translated cranially approximately 2 cm. Pelvis was scanned with a 64-line, spiral, HR-CT (Aquilion One, Toshiba, Japan) in 1-mm layers before surgery. L4 nerve branch, L5 nerve root and lumbosacral trunk were segmented using commercially available image analysis software (Synapse Vincent; Fujifilm Cooperation, Tokyo, Japan). The Stereolithography file format data of segmented lumbosacral nerves were transferred to the navigation workstation. The navigation procedure was performed using a computer navigation system (Stryker Navigation System II-Cart, Stryker, Kalamazoo, MI, USA) and a mobile 3D C-arm equipped with a flat-panel detector (Ziehm Vision FD Vario 3D, Ziehm Imaging, Nuremberg, Germany). The patient was positioned supine on the radiolucent operation table. First, a reference clamp was placed on the contralateral iliac crest. The scan area was fluoroscopically determined aiming at the center of S2 vertebral body in the anterior-posterior and lateral positions. The C-arm was connected to the navigation system and calibrated by registering three points on the detector using a pointing device. Then, 110 single images from a right cylindrical volume of 12 cm in diameter and 12 cm in height were acquired during a 60-s automated orbital scan of 135°. After data transfer to the navigation system, image matching between the preoperative CT data and the intraoperative 3D fluoroscopy image volume was performed. The anterior approach to the sacroiliac joint was performed. A surgical incision of 12 cm was placed along the crest from the anterior-superior iliac spine to the crescent fracture. The position of the sacrum and lumbosacral nerves was checked using a navigation pointer (Fig).
The dislocated sacroiliac joint was reduced with axial traction of the leg and inner rotation of the pin fixed to the iliac crest. The joint was fixed temporally by a Kirschner wire. After grafting of the bone chip harvested from the inner side of iliac bone, the joint was fixed using an anatomically shaped sacroiliac plate (Sacroiliac plate; NexMed International Co., Ltd. Chiba-city, Japan). Two cancellous screws of 6.5 mm diameter were inserted to the sacral ala. To avoid screw perforation to the sacral canal, neural foramen and sacroiliac joint, the direction of a screw drill was controlled using the navigated drill sleeve. Two cortical screws of 4.5 mm diameter were inserted to the iliac brim. Crescent fracture was fixed using a 4-hole reconstruction plate on the inner surface of the iliac crest. The operation time was 189 minute. The intraoperative blood loss was 750 ml. There was no postoperative complication including nerve palsy, infection, symptomatic deep vein thrombosis and pulmonary embolism. Postoperative CT revealed no screw perforation to the sacral canal, neural foramen and sacroiliac joint.

Discussion: Atlahan D et al. reported that the distance between the lumbosacral trunk and sacroiliac joint ranged from 4 to 14.8 millimeters at the level of L4 nerve branch and L5 nerve root merged and it ranged from 4.2 to 19 mm at the level of promontorium. This wide variation of position of lumbosacral nerves has potential risk to be damaged during exposure and operation. If the individual position of lumbosacral nerves was estimated preoperatively, safer exposure and operation could be achieved. Most computer systems for orthopaedic trauma surgeries focused on the visualization of bony structures, not soft tissues, although preoperative CT images have much information of soft tissue structures including muscles, arteries and nerves. We believe that preoperative plan including assessment of the proximity of lumbosacral nerves is valuable to determine the method of stabilization and avoid iatrogenic nerve injury. Intraoperative visualization of lumbosacral nerves by computer navigation was also useful to recognize the “at risk area” for nerve injury around the displaced sacrum. Difficulty in patient-to-image registration had limited the application of computer navigation system to orthopaedic trauma surgeries. 2D and 3D fluoroscopic navigation system enabled surgeons to use the navigation system for orthopaedic trauma.
surgeries because they use intraoperatively acquired fluoroscopic images. A drawback of 2D and 3D fluoroscopic navigation system is inability to make preoperative plan. A novel 3D fluoroscopic navigation system using the flat panel detector C-arm has made it possible to superimpose preoperative CT-based plan on intraoperative 3D fluoroscopic images of pelvis with an accuracy of 0.8 millimeters. Thus we applied the CT-3D-fluoroscopy matching navigation to anterior sacroiliac plate fixation for pelvic ring fractures. The CT-3D-fluoroscopy matching navigation system with visualization of lumbosacral nerves was useful to treat type C pelvic ring fracture using the sacroiliac plate through anterior approach.