Preface

Computer-assisted techniques were introduced in spine surgery in the 1990's to improve accuracy and safety of operative procedures. Several reports on clinical results of computer-aided screw insertion in the cervical, thoracic, and lumbar spine as well as the sacro-iliac joints are available. They show a significant decrease of screw malplacement rates as compared to conventional insertion techniques. The quality of preoperative planning of spinal procedures has improved markedly by using computer navigation systems. Drawbacks, reliability problems, and safety issues of computer navigation are discussed. In the near future, the use of computer guidance for minimally invasive and percutaneous spine procedures is expected to be clinically accepted globally.

In the past decade, great advances have been made that has taken navigation of the spine (or localization) to a new height. Also known as "computer-assisted, image-guidance," navigation technology is advancing at a rapid rate. More powerful and elegant than simple x-ray technology, spinal navigation technology uses a computer and radiographic studies (x-rays) of the patient to allow the surgeon to know precisely where he/she is at all times.

Spinal navigation technology enables the surgeon to more accurately place spinal instrumentation, perform decompression (e.g. eliminate pressure on nerves), remove tumors, and other tasks. Three-dimensional models of a patient's own spine appear on a computer screen with virtual representations of real surgical instruments that the surgeons have in their hand. Surgeries can even be planned 'virtually' on the computer before a patient even goes to sleep under anesthesia.
For example, screw diameter, length, and other measurements can be made with greater accuracy.

The future of spinal navigation is exciting. Rather than send a patient for an preoperative CT or MRI scan, in the future, surgeons will be able to obtain images in the operating room that can instantly create computer models of the patient's spine. These models can be used to help navigate the spine during surgery. Intraoperative CT, MRI, and fluoroscopy-based CT offer great potential. The end result is enabling the surgeon to visually “travel” in and out of a patient's spine on computer, thereby allowing them to see things that the human eye cannot during a typical surgery. As spinal navigation technology advances, newer minimally invasive techniques will become available.

Today, more than a dozen companies offer surgical navigation systems for various types of interventions along the spine that involve the placement of screws. As the pedicle offers a strong point of attachment to the spine, several instrumentation systems using screws that go through the pedicle into the vertebral body have been developed to provide internal stability. All pedicle screw systems share the risk of damage to adjacent neural structures as a result of improper screw placement. A computer-assisted system allowing precise preoperative planning and real-time intraoperative interactive image localization has been implemented for spine instrumentation to optimize transpedicular spine fixation.

Spinal fusion and Pedicle screw fixation techniques are usually used in the case of vertebral fractures, dislocation, scoliosis, kyphosis, spinal tumor, failed previous fusion (pseudarthrosis) and for the severe back pain that doesn’t respond to other therapies. The biggest challenge in the surgery is maintaining proper alignment of
the so-called pedicle screws. The pedicle is surrounded by many sensitive structures and is not visible during pedicle screw insertion. Screw malposition is the primary cause of complications like pedicle wall perforation, nerve roots and cord impingement, and very rarely damage to vascular structures. Nerve root and cord impingement alone occurs in 6.6% of all placements. Therefore exact location of initial point of entry and screw orientation is of great importance.

Many computer-assisted techniques such as Robotic method, Fluoroscopic method, Virtual fluoroscopic method, Rapid prototyping etc. have been developed in recent years to help doctors get the best possible alignment of pedicle screws. Even though these methods claim above 90-percentage accuracy, setting up of these instruments are very costly and have side effects like exposure to radiation. Even though radiation hazard is eliminated in imageless systems, they are very expensive. A less expensive technique with minimal hardware is proposed here to locate the initial point of entry and to track the trajectory of the pedicle screw in real time with the help of image processing and Computer graphics techniques.

The Chapter 1 deals with the general aspects of computer assisted surgery and the anatomy of the spine. Chapters 2 and 3 describe various aspects of pedicle screw fixation, whereas Chapter 4 and 5 explain the basis of spinal navigation. The Chapter 7 is entirely devoted for the description of the newly developed software. Cadaveric and clinical studies to validate the accuracy of the software are given in Chapter 8. Chapter 9 gives lot of insight into the advantages of computer assisted pedicle screw placement. The summary and future scope of computer assisted spinal surgery is given in the Last Chapter.
Most of the work presented in this thesis have either been published / communicated in international / national journals or presented in international / national conference or are in the process of publication.

List of publications

1. "Computer assisted pedicle screw fixation, a cadaveric study"

2. "Computer Assisted Surgery Growing In Asian Countries"

3. "Navigation the future – surgery using computer"

4. "Report of the first Asian meet for computer assisted orthopaedic surgery"

5. "Computer assisted communication system with the help of G.I.S. for pre-hospital care in trauma and road traffic accidents"

6. "A less expensive system for computer assisted pedicle screw fixation – cadaveric study"
   P S John (published in the special issue of Euro spine)

7. "Computer assisted pedicle screw fixation clinical experience with a newly developed software"

8. "Computer assisted pedicle screw fixation"
9. "Enhancement of ultrasound induced cell proliferation by neurotransmitters"


10. "Enhanced bone healing after head injury: involvement of neurotransmitters"


11. "Computer assisted orthopaedic surgery growing in Asia"

P S John, Asian Journal of Orthopaedics and Rheumatology Volume 2, Number 1, (April-June 2005)

12. "Computer assisted pedicle screw fixation: clinical experience with a newly developed software"


13. "Navigating the Future – Surgery using Computer"


14. "Cervical Spine Injury In Head load workers"

P S John, Indian Council of Medical Research Bulletin (1980)

15. "Cervical discectomy without fusion"


16. "Experience with JESS (Joshy’s External Stabilization System) in CTEV (Congenital Talipes Equinovarus) below the age of one"

P S John and Bibu George, Journal of KOA (2001)

17. "The spectrum of psoriatic arthropathy"

18. “Arthrodistraction in Perthes’ disease”

19. “Side Swipe Injwtes-A comparative study”
   P S John and Asokan, Journal of KOA, Vol.12 No.2

20. “A new and indigenous device for distal locking”

21. “Infected Interlocking nail-a difficult problem to solve”

22. “Neoangiogenesis in peripheral vascular disease by Ilizarov technique”

23. “Histologically negative Tuberculosis-a myth or reality”

24. “Osteochondroma of lumbosacral spine with intra and extra-canalicular extension and canal compromise”

25. “Radio-ulnar locking-a new approach to the management of unstable fractures of the distal radius”


27. “Solid Interlocking nail in treatment of open Tibial fractures-a comparative study”

28. “Navigation – the surgical toolbox of future”
29. "Physiological Distraction in the Management of Malunited Fractures of Distal Radius"


30. "Cadaveric Study on Pedicle Screw placement using a newly developed software"

P S John, Paper presented in the 3rd CAOS International Meet, Marbella, Spain (19th June 2003)

31. "Early experience with a newly developed software for pedicle screw placement"


32. "Experimental study on a newly developed software for pedicle screw placement"


33. "Invited talk on Computer assisted spine surgery in FDA"

P S John, US FDA, Washington DC, USA (21st June 2004.)

34. "Paired point matching under fluoroscopic guidance in pedicle screw fixation- a clinical study"


35. "Enhancement of ultrasound induced cell proliferation by neurotransmitters"


36. "Enhanced bone healing after head Injury: Involvement of neurotransmitters"

37. "What is CAOS?"

P S John, 2nd Asian Meet of Computer Assisted Orthopaedic Surgery at Shangri La Roza Hotel, Singapore on (15th April, 2005)

38. "Computer Assisted Spine Surgery"

P S John, The 2nd Asian Meet of Computer Assisted Orthopaedic Surgery at Shangri La Roza Hotel, Singapore on (15th April, 2005)

39. "Computer Assisted Pedicle Screw fixation – Clinical experience with a newly developed software"

P S John, poster presented in the 5th Annual Conference of CAOS – International at Helsinki, Finland, June 19 – 22, 2005

40. "A novel computer assisted technique for pedicle screw insertion"


41. "Guest lecture on Spine navigation"

P S John, Spanish CAOS annual meeting "18th (Nov 2005)

42. "Computer Assisted Spine Surgery"

P S John, 3rd Annual Meet of Asian Society for Computer Assisted Orthopaedic Surgery at Kaohsiung University, Taiwan on 22nd (April, 2006.)

43. "Spine Navigation – Past, Present & Future" in the


44. "A Novel Computer assisted technique for pedicle screw insertion"